US005836044A

United States Patent [19]

Sinnett et al.

[11] **Patent Number: 5,836,044**

[45] **Date of Patent: Nov. 17, 1998**

[54] **SURFACE CLEANER AND COLLECTOR SYSTEM**

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[73] Assignee: **Chapman Corporation**, Portland, Mass.

[21] Appl. No.: **451,529**

[22] Filed: **May 26, 1995**

[51] **Int. Cl.**[6] **B08B 5/02**

[52] **U.S. Cl.** **15/309.1**; 15/316.1; 15/409

[58] **Field of Search** 15/306.1, 309.1, 15/316.1, 409

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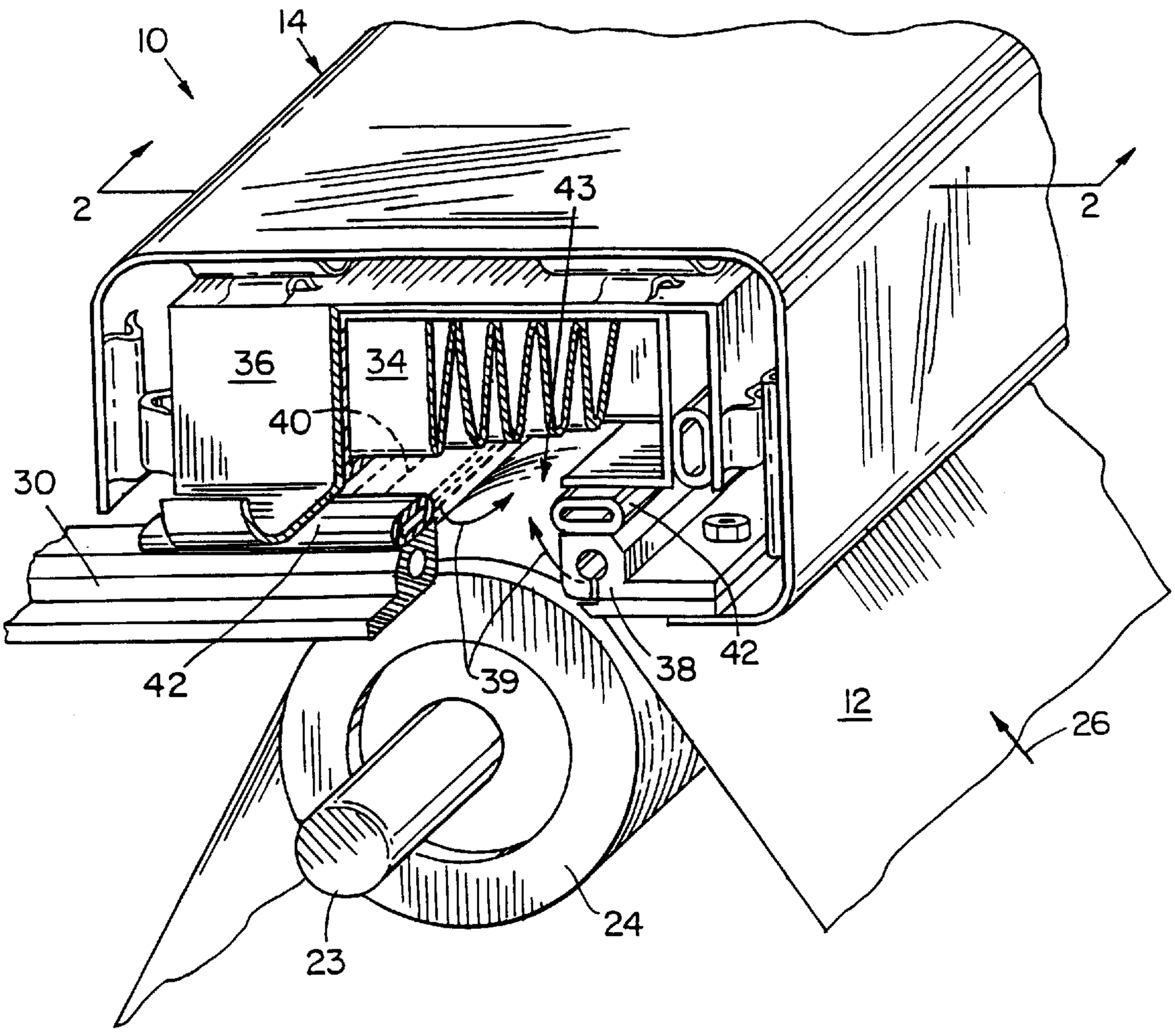
Primary Examiner—Chris K. Moore
Attorney, Agent, or Firm—Iandiorio & Teska

[57] **ABSTRACT**

A surface cleaner and collector system includes: a chamber having an opening for receiving a surface to be cleaned; at least one pressurized air delivery system proximate the surface for establishing an air flow for loosening and entraining contaminants on the surface; a sealing system for sealing the chamber and creating a positive pressure therein; and a collector for trapping the entrained contaminants and passing the air flow.

34 Claims, 14 Drawing Sheets



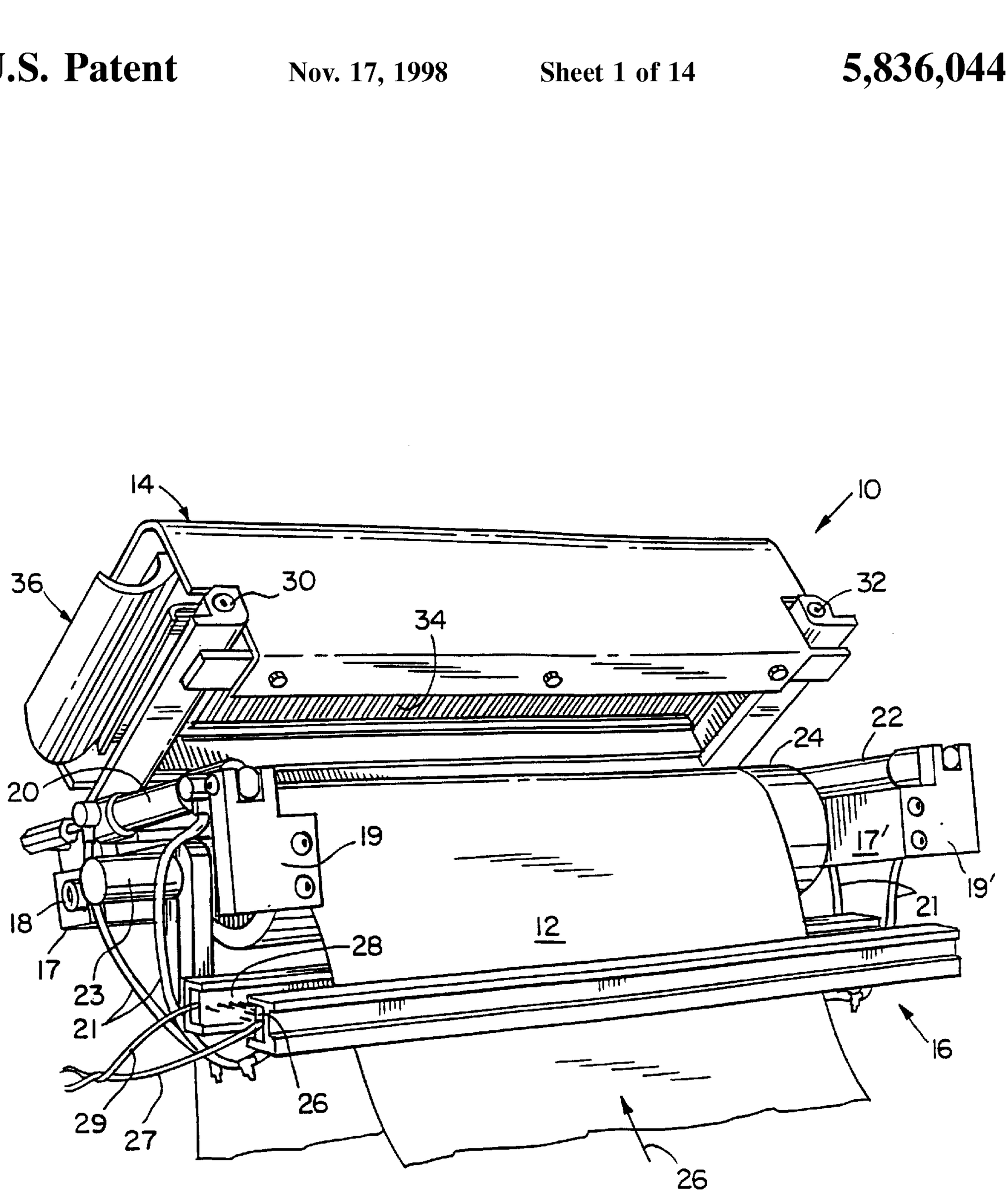


FIG. 1

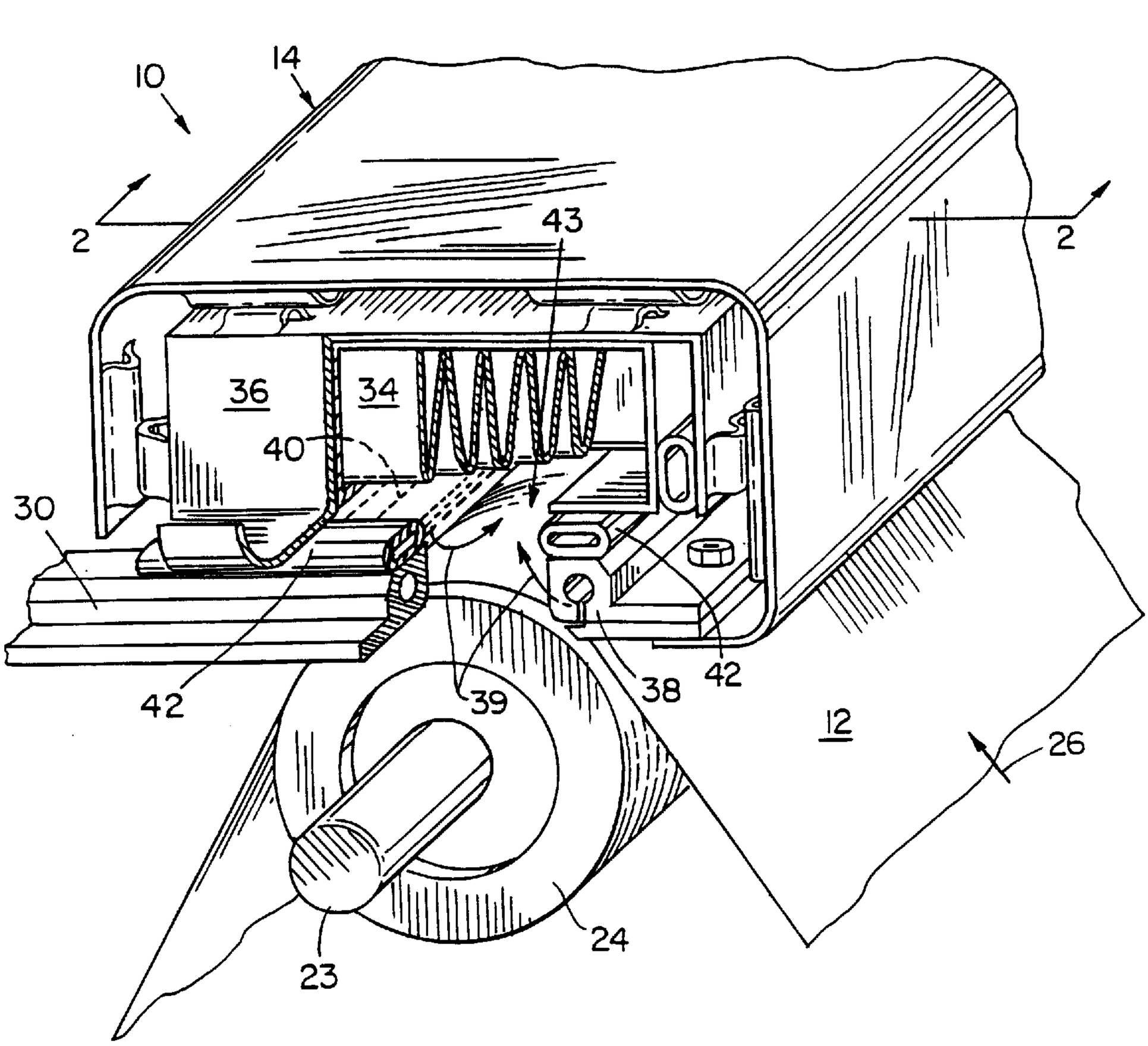
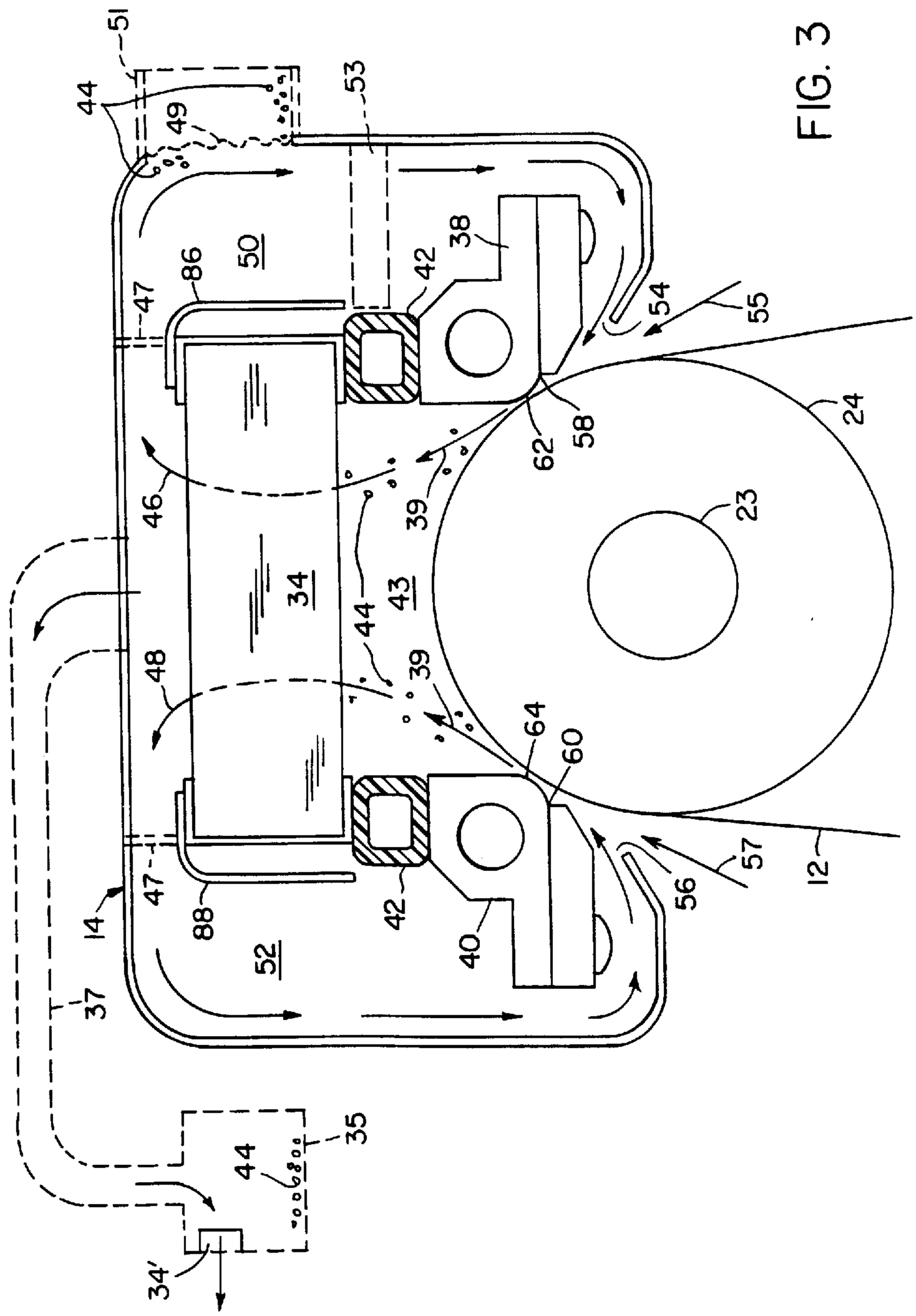


FIG. 2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46
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14
37
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12
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34'

FIG. 3

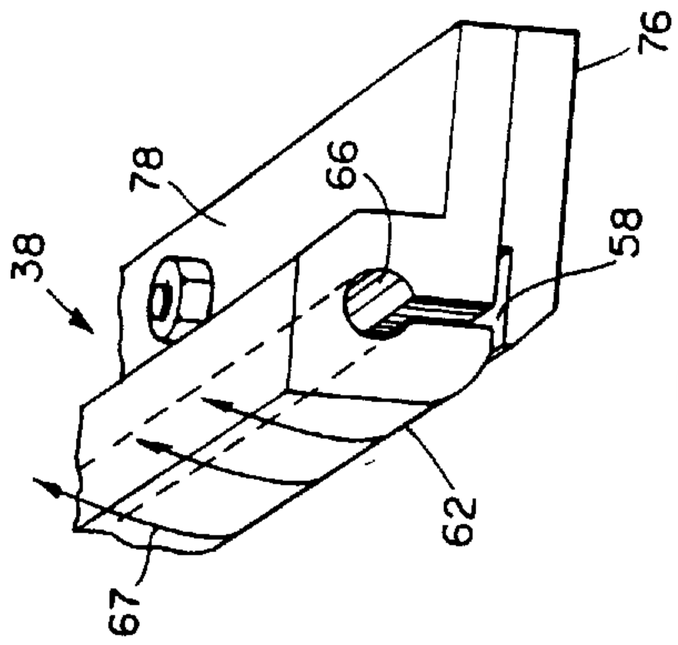


FIG. 5

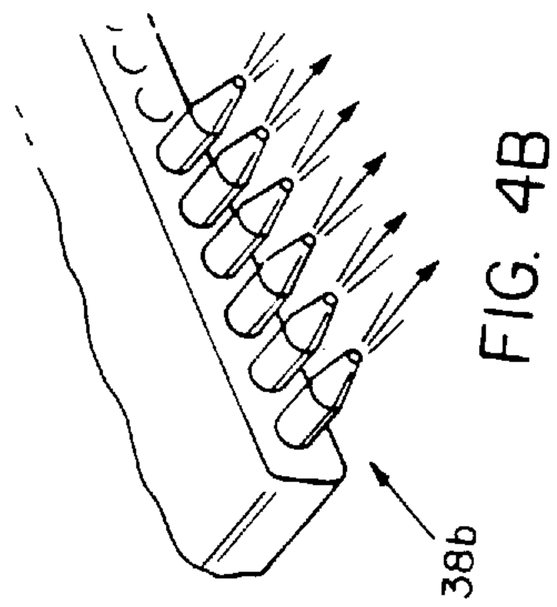


FIG. 4B

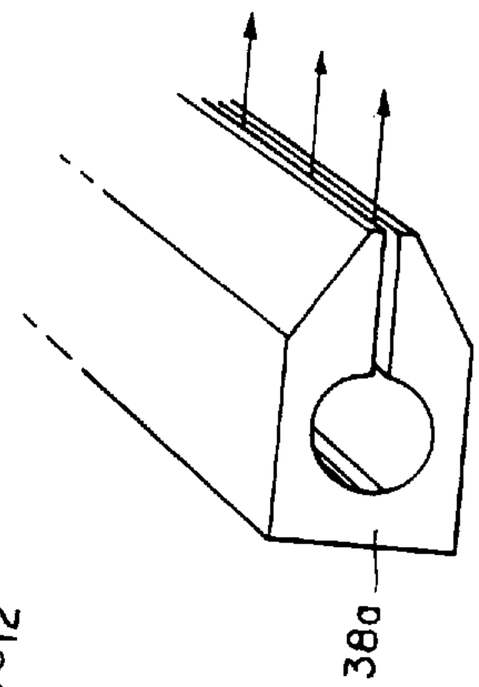


FIG. 4A

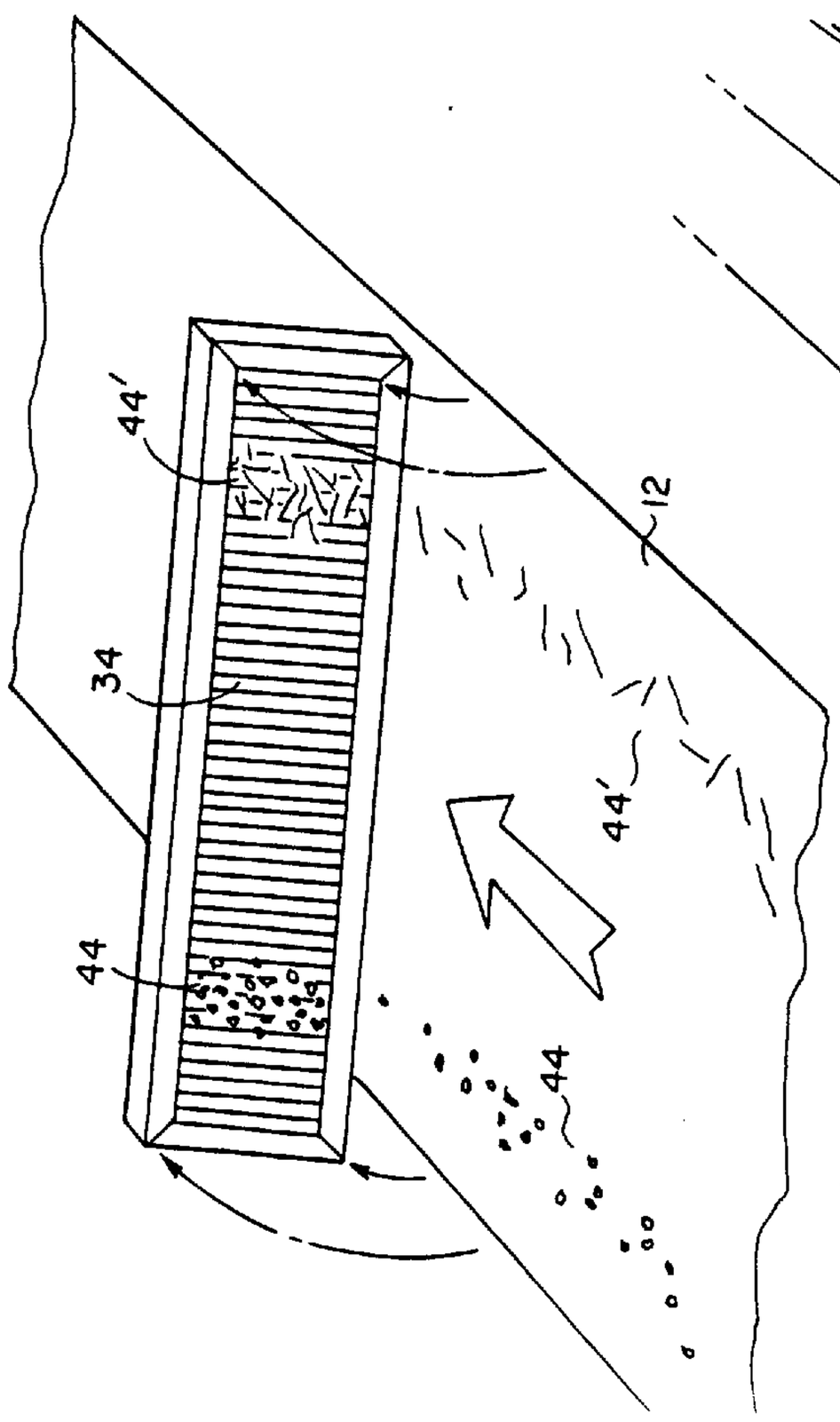


FIG. 3A

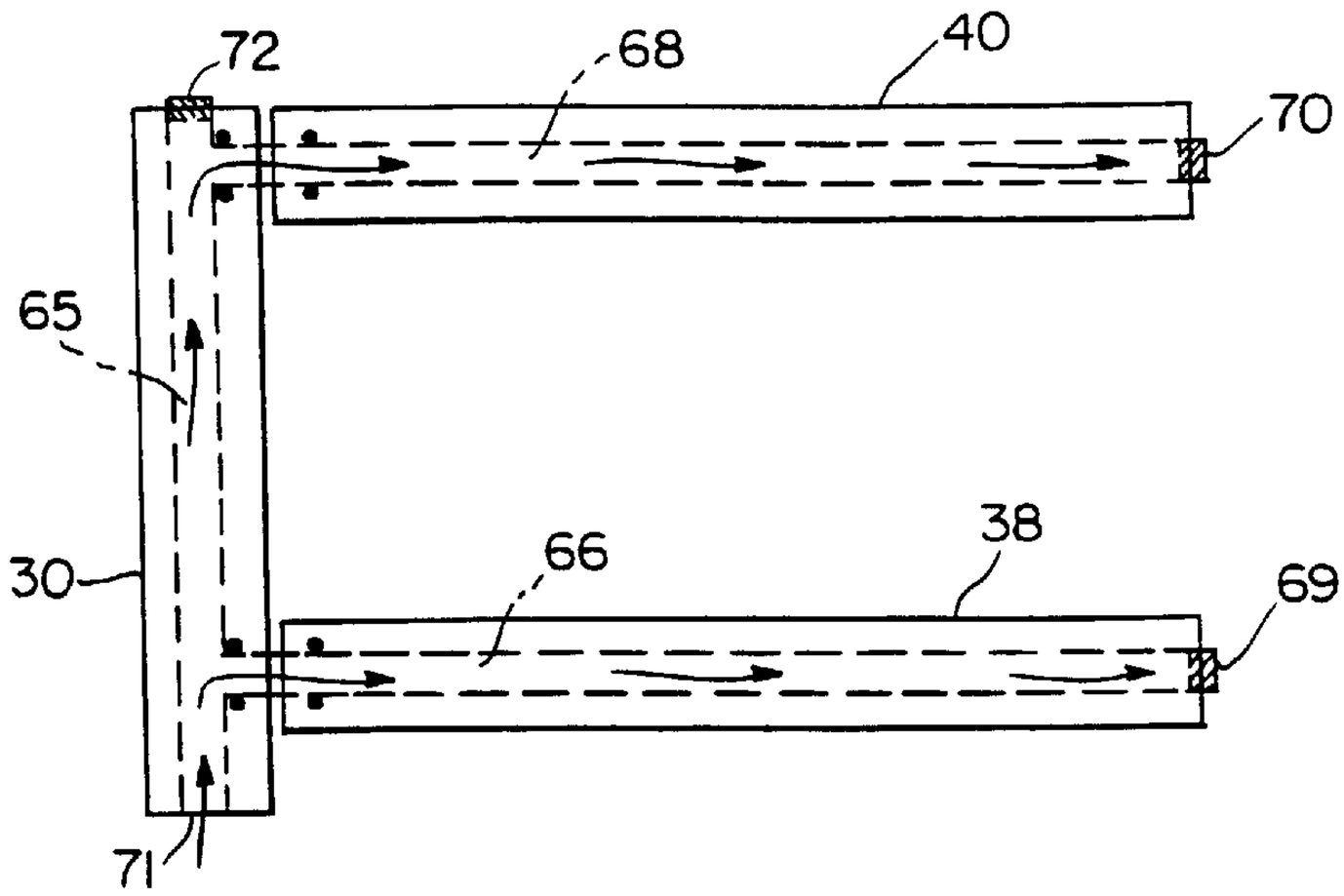


FIG. 6A

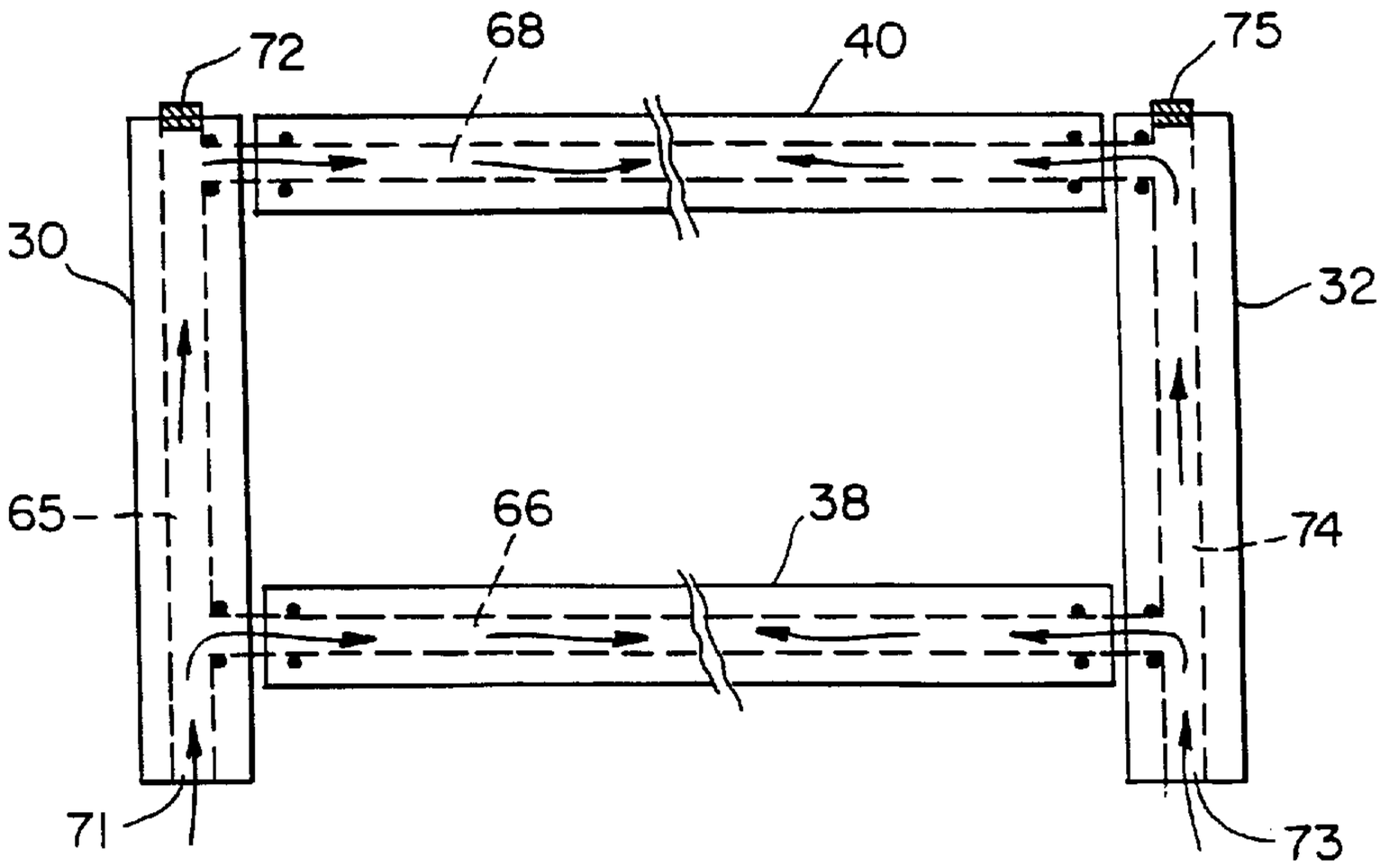


FIG. 6B

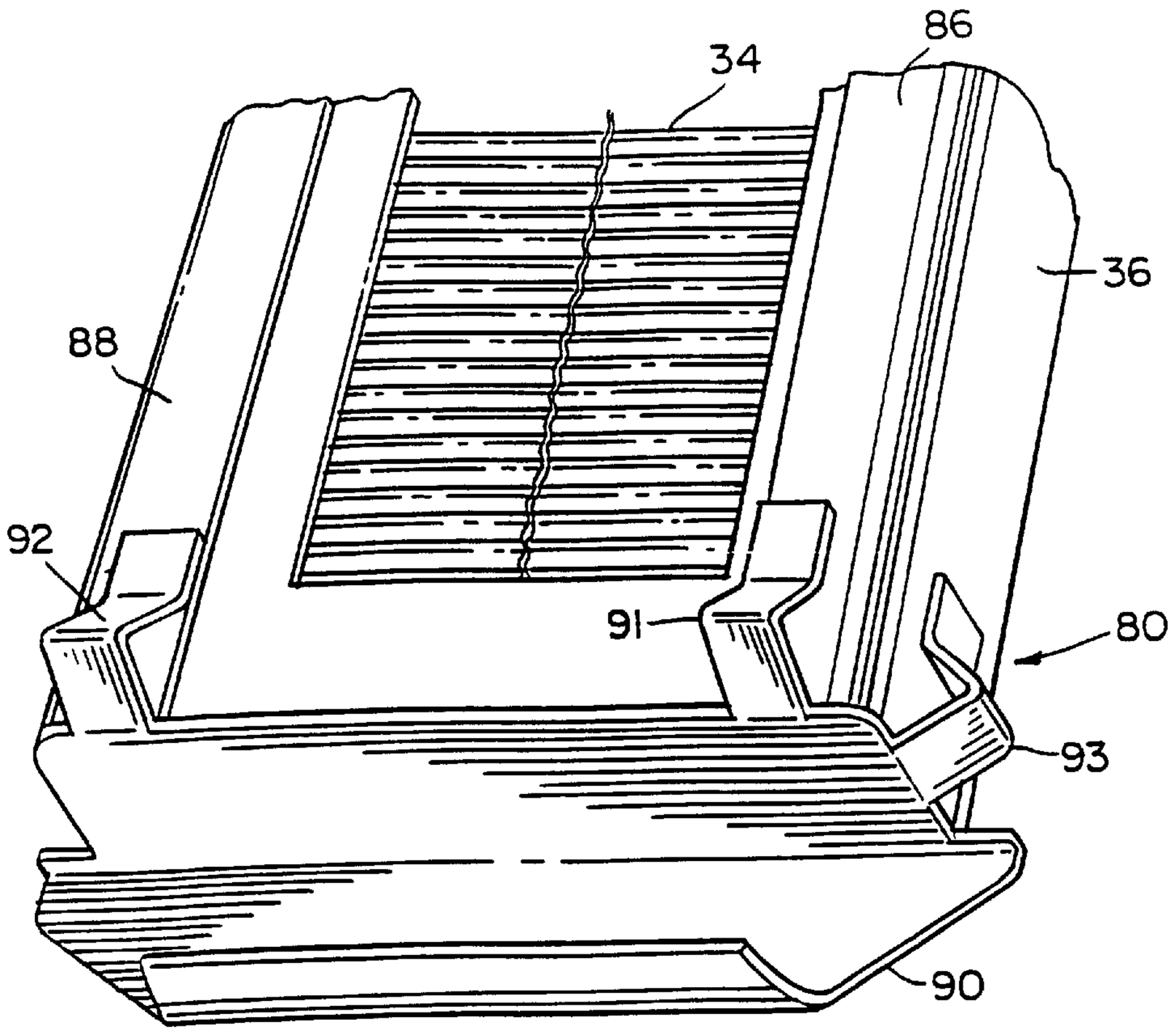


FIG. 7A

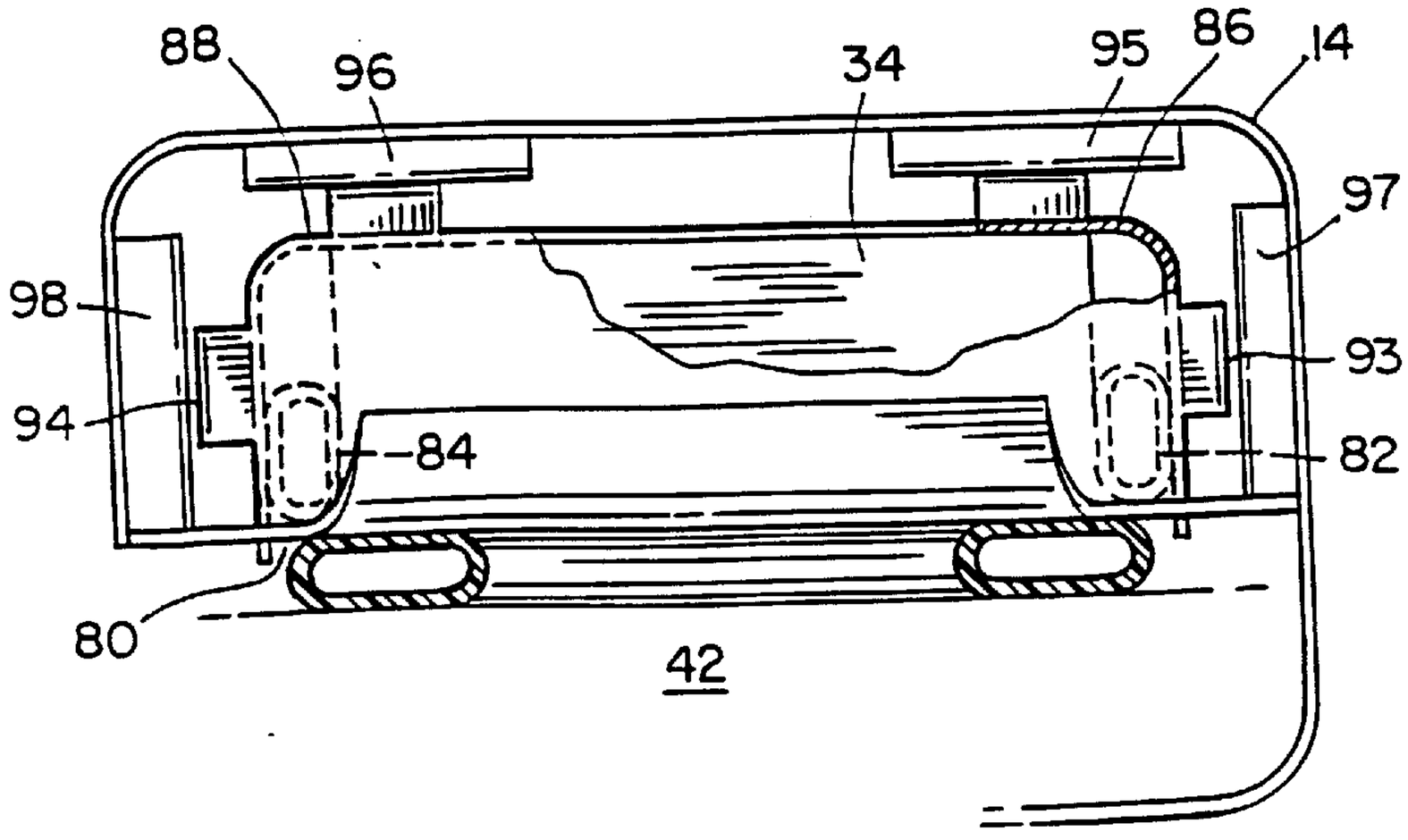


FIG. 7B

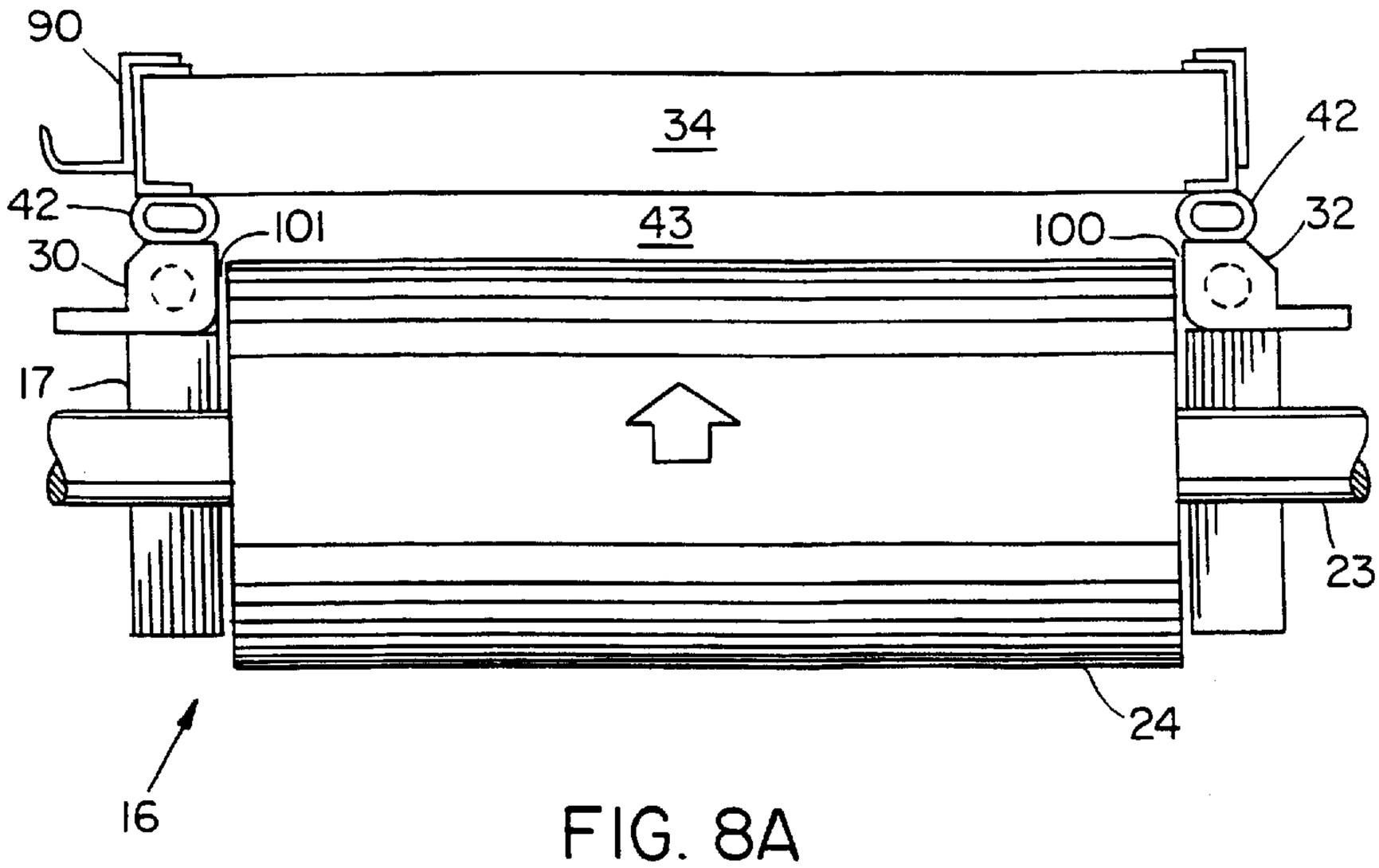


FIG. 8A

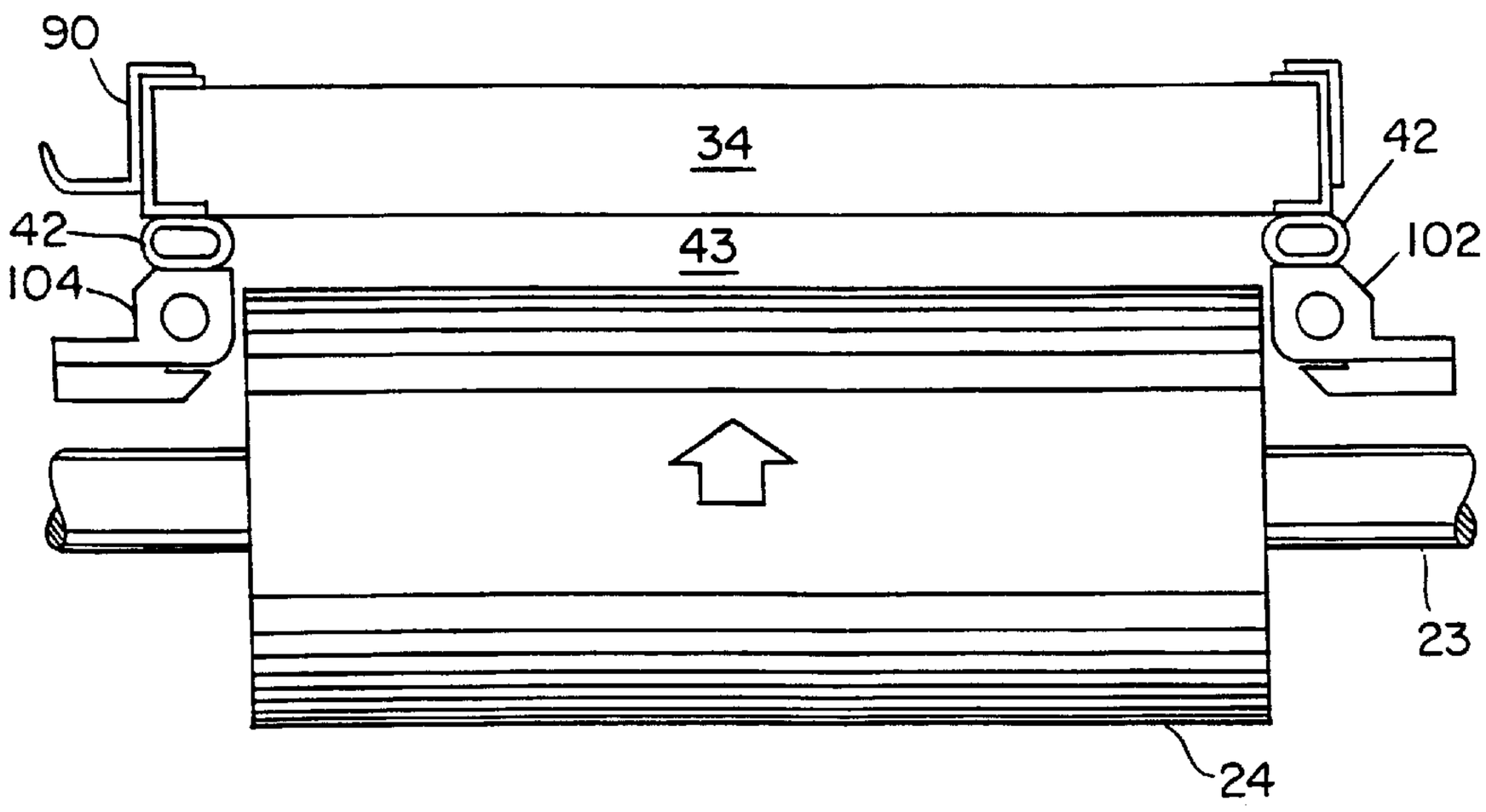


FIG. 8B

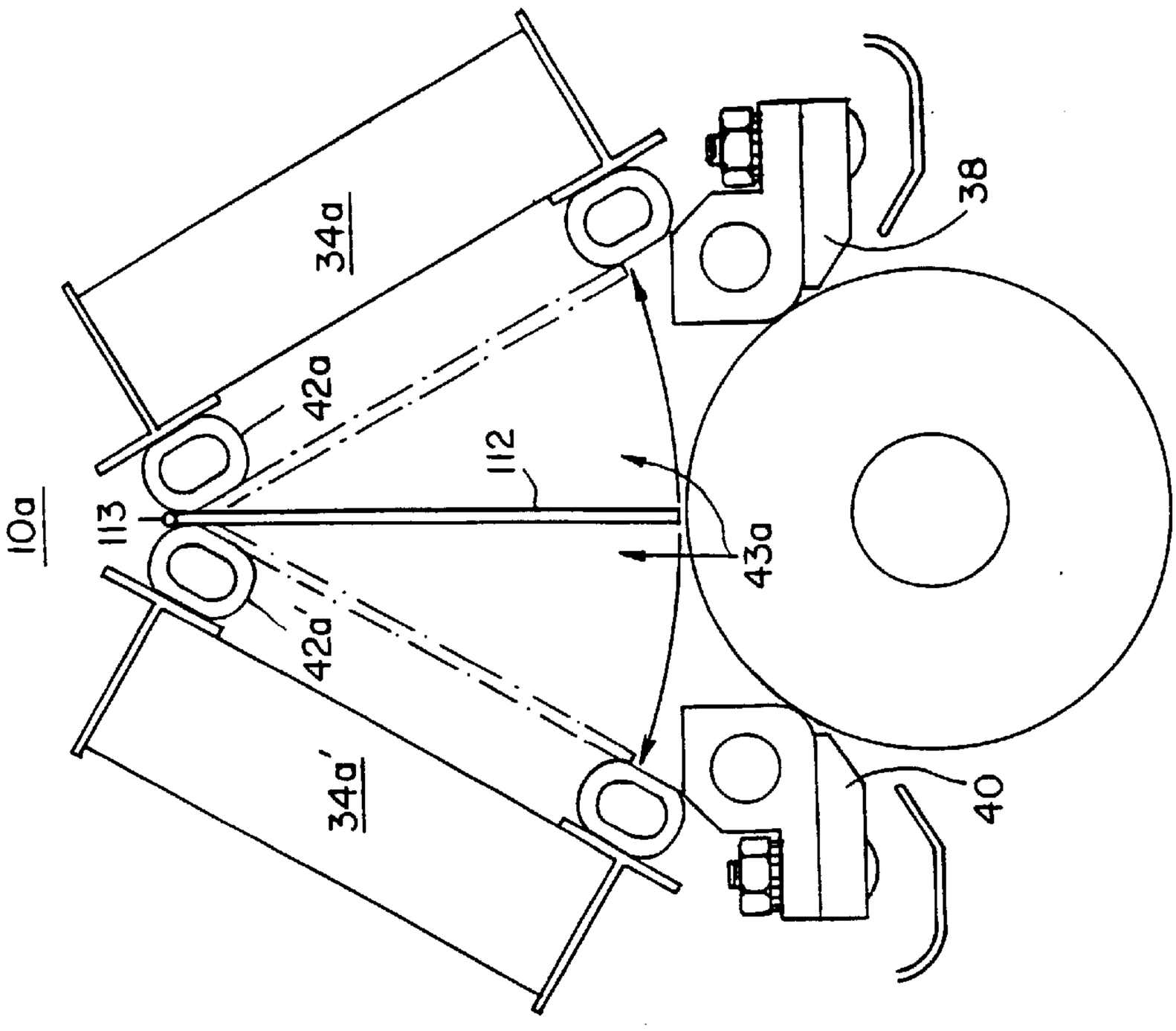
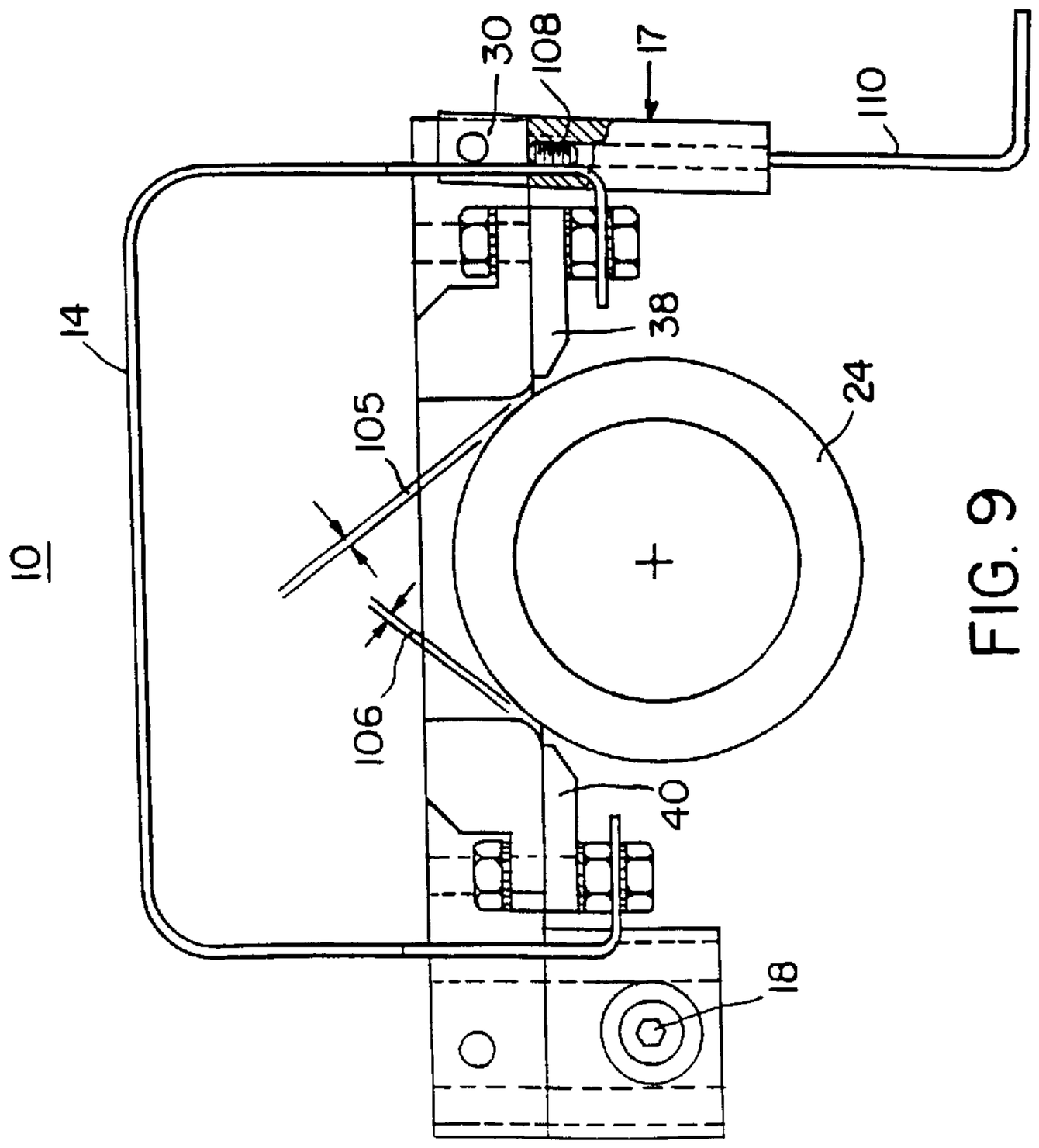

10a
113
34a
42a
112
43a
42a'
34a'
38
40

FIG. 10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14
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108
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105
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FIG. 9

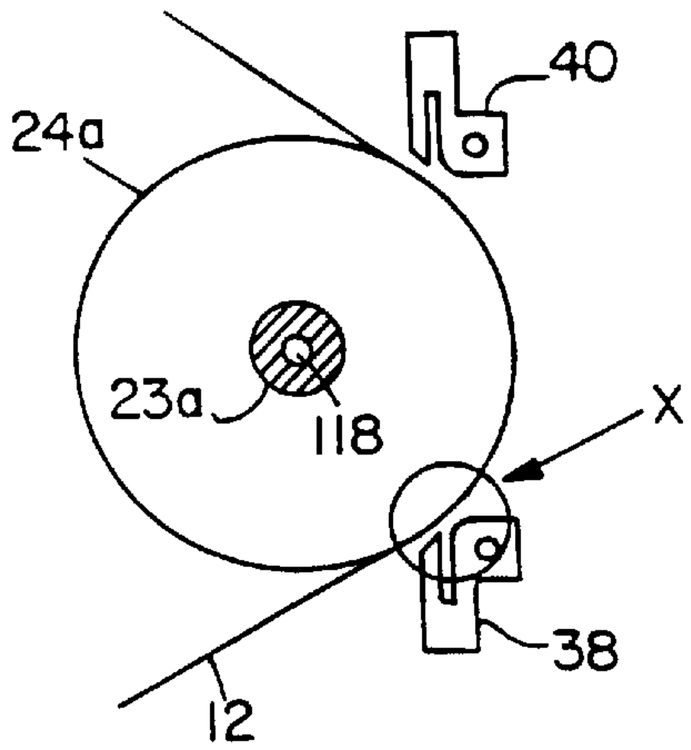


FIG. 11B

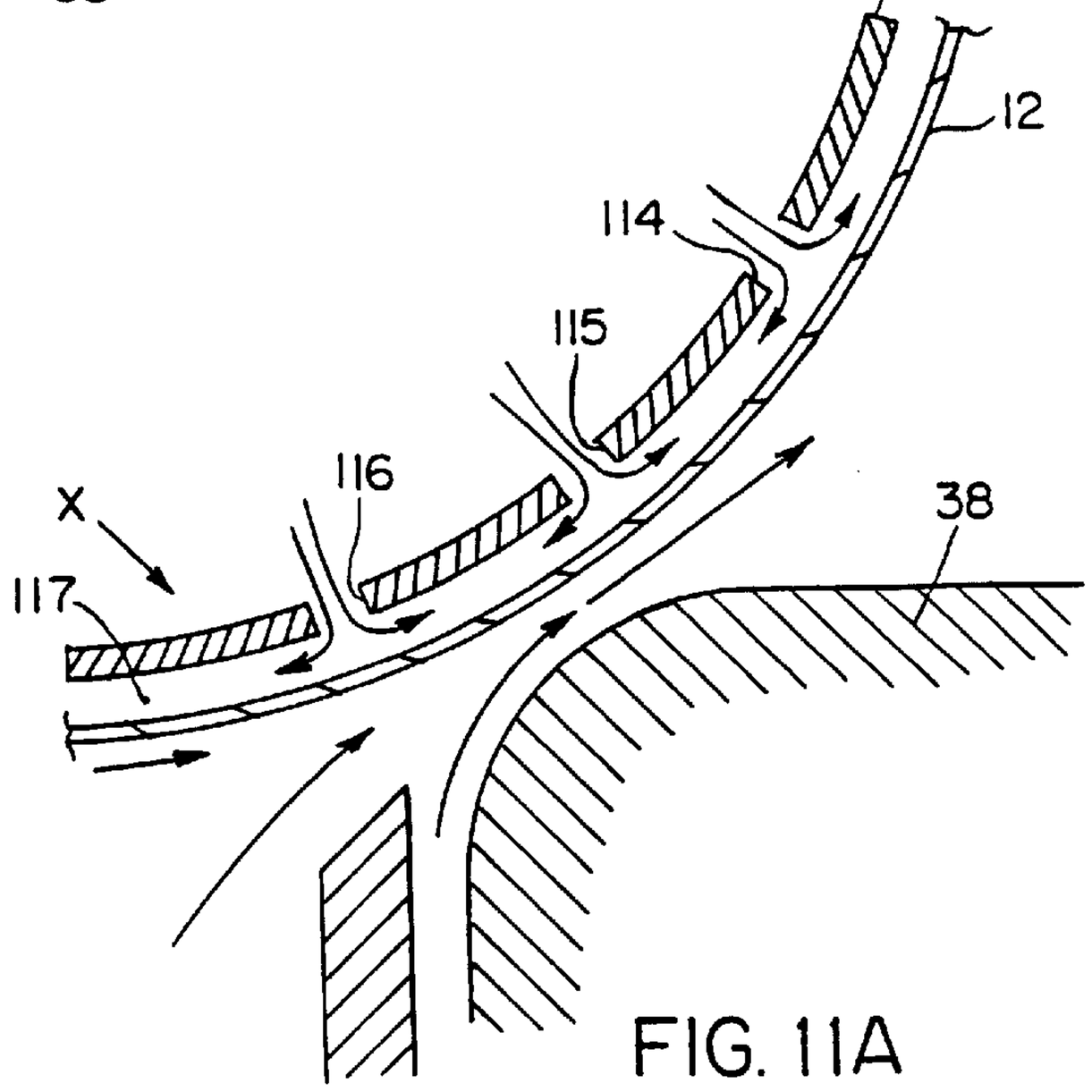


FIG. 11A

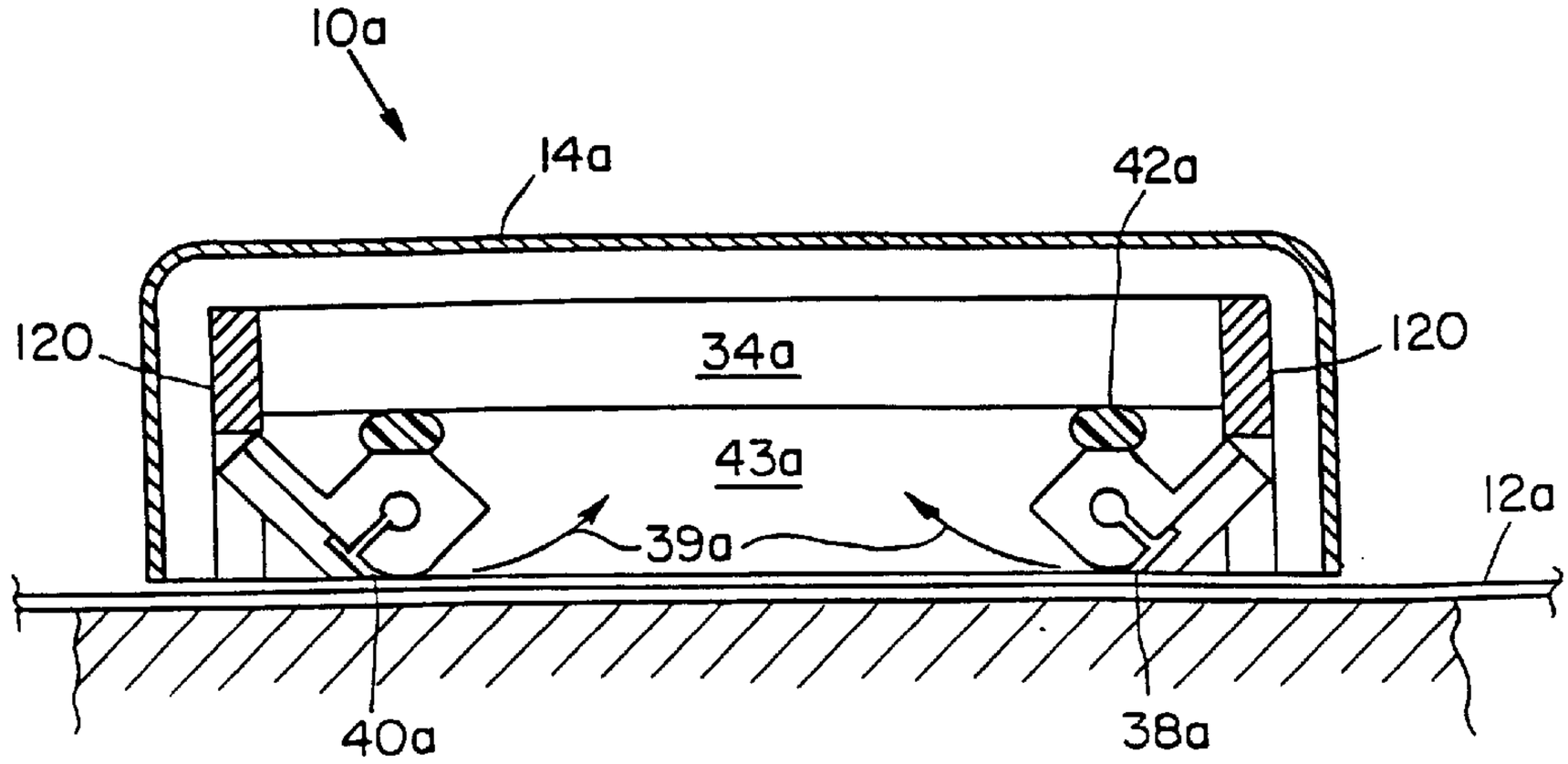


FIG. 12A

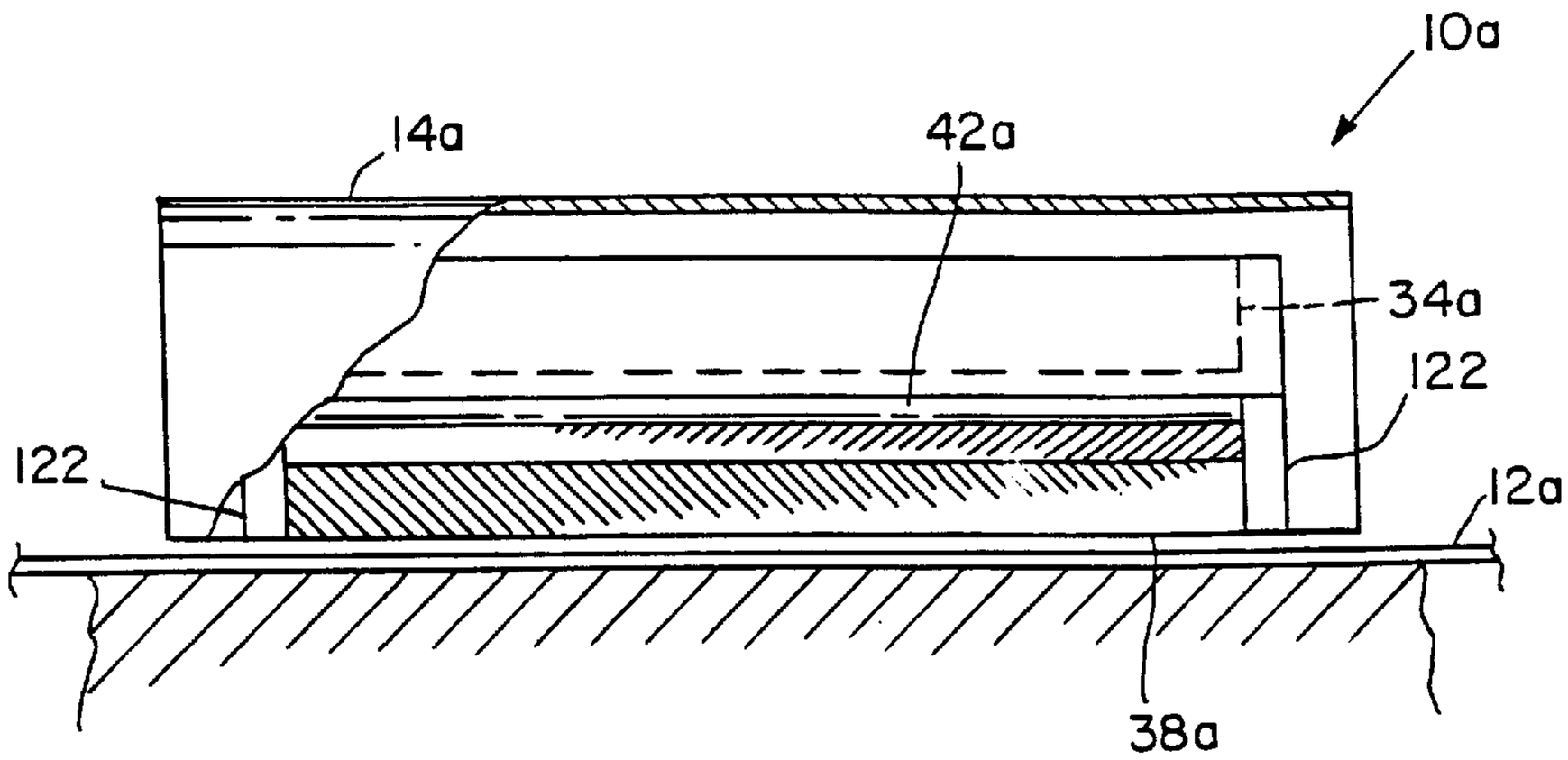


FIG. 12B

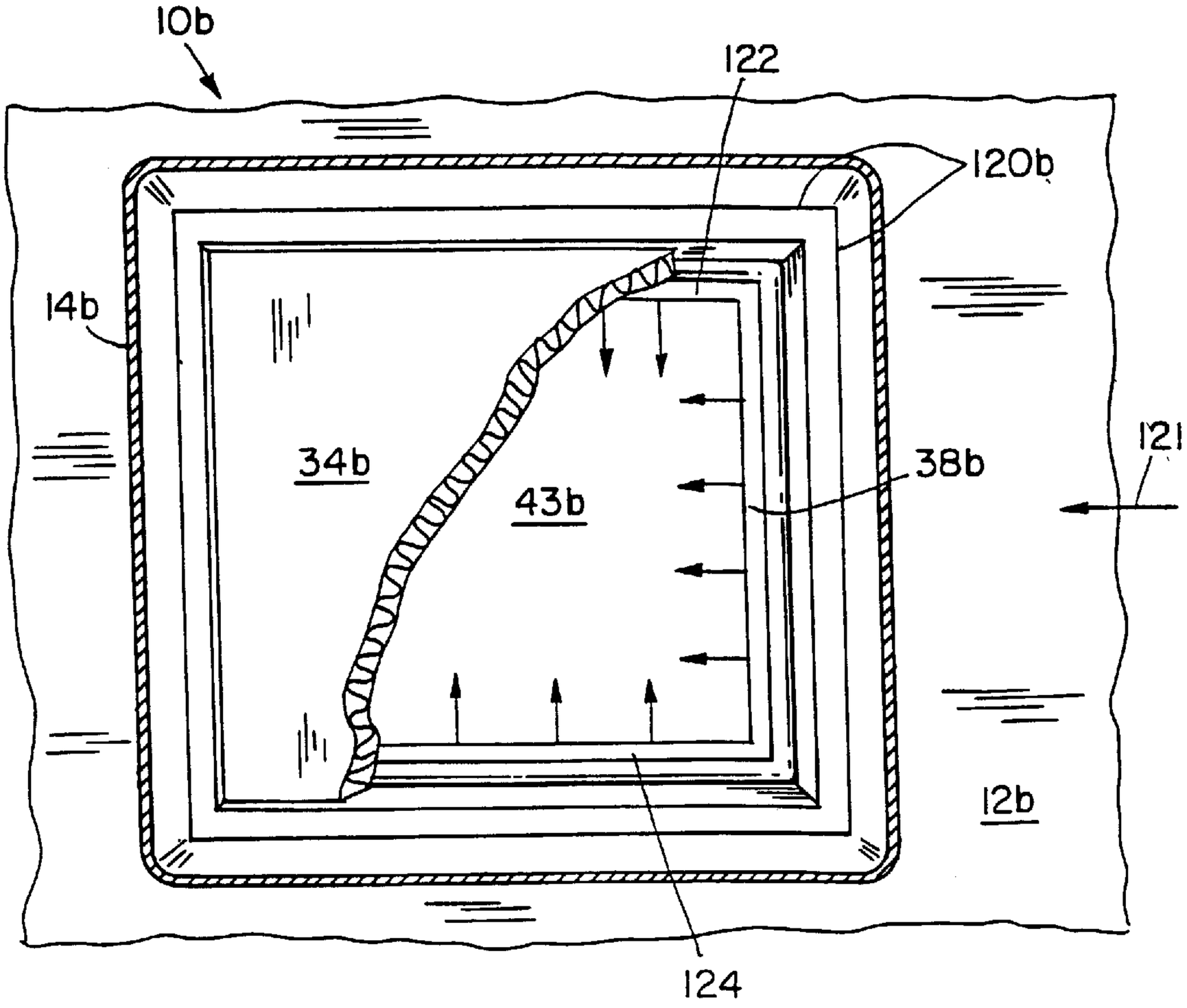


FIG. 13A

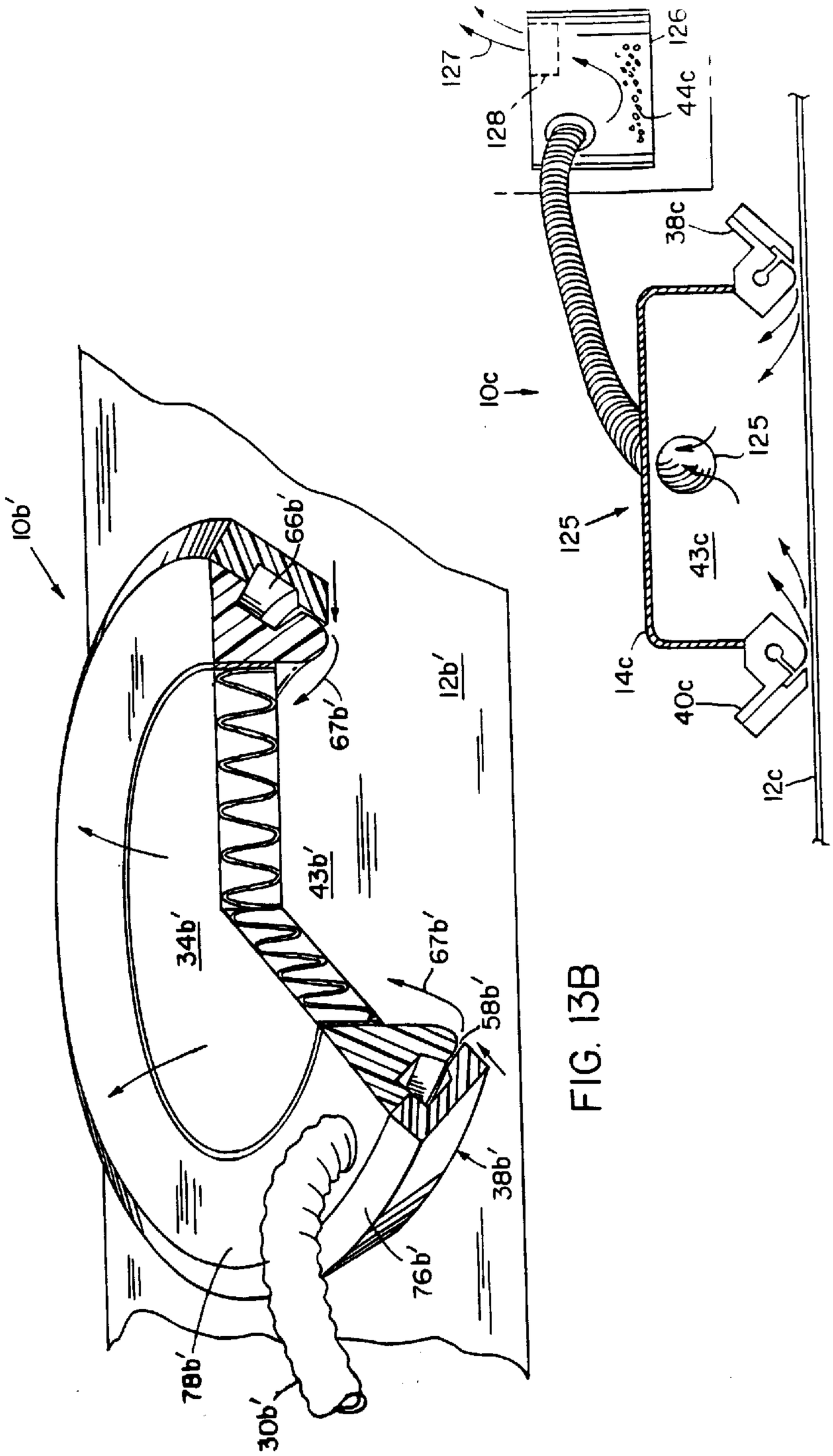


FIG. 13B

FIG. 14

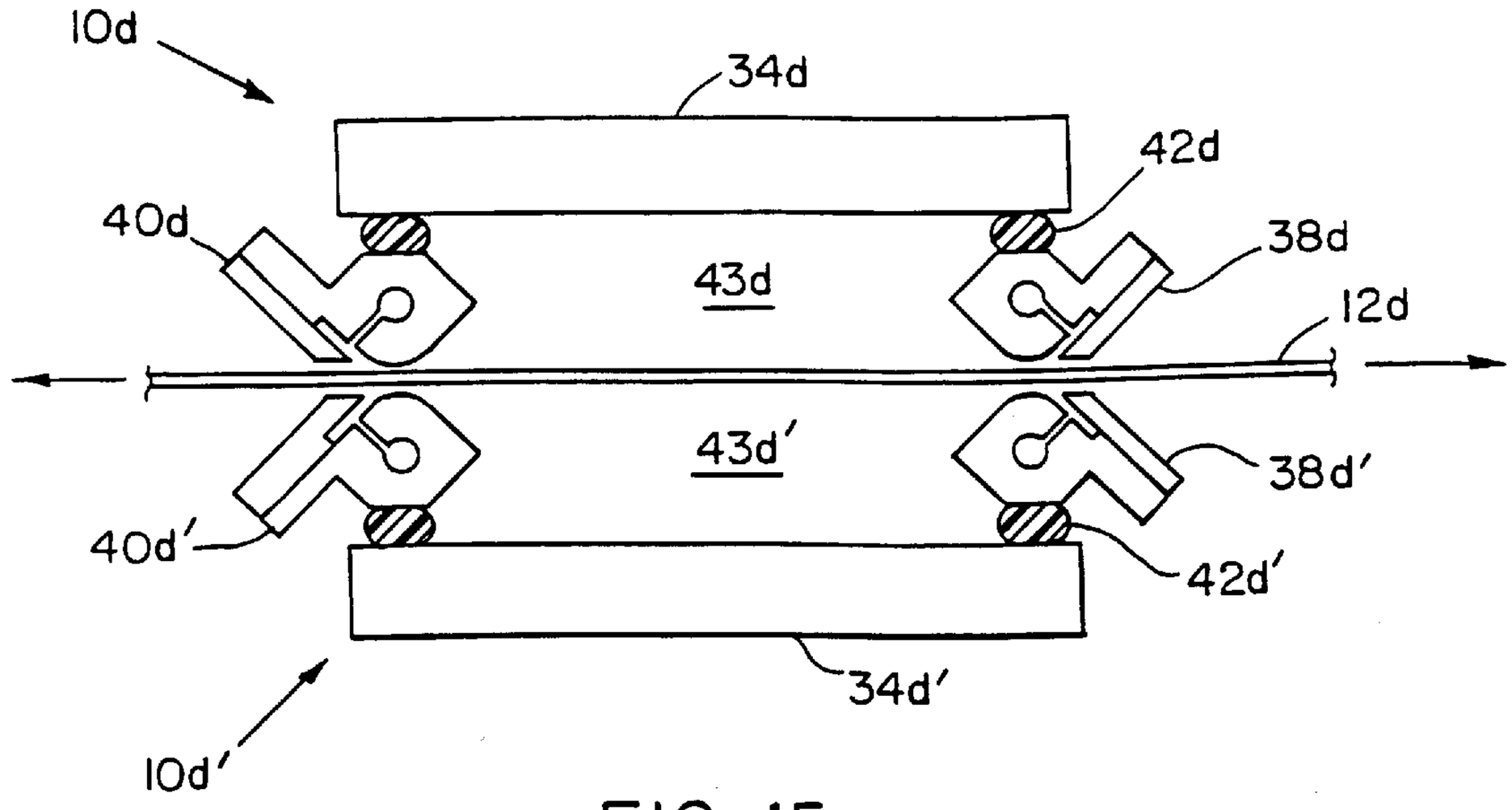

10d
34d
42d
40d
38d
43d
12d
43d'
38d'
40d'
42d'
34d'
10d'

FIG. 15

122d
132
10d
130
34d
120d
42d
43d
38d
12d
43d'
40d'
38d'
120d'
10d'
42d'
34d'

FIG. 16

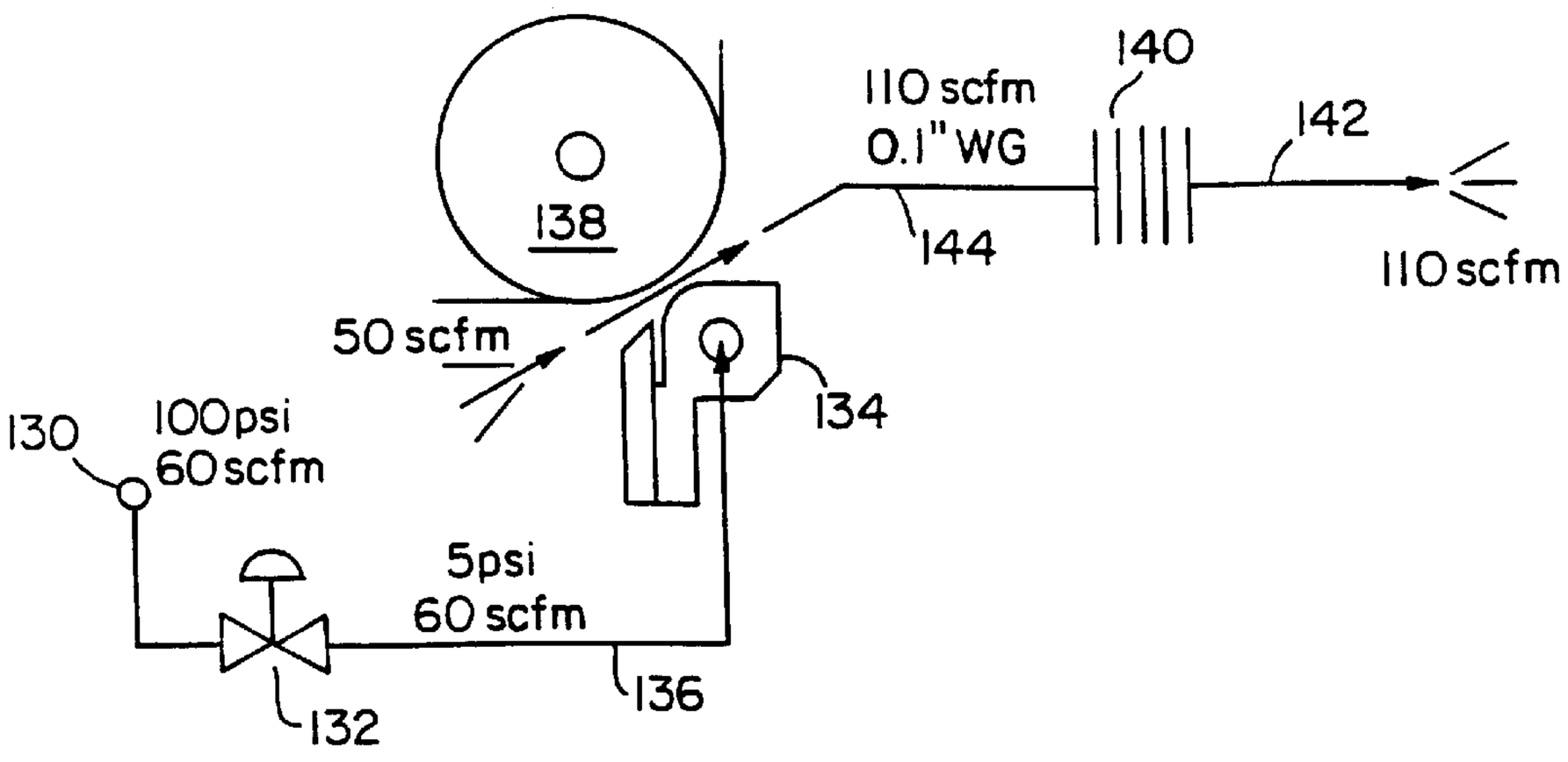
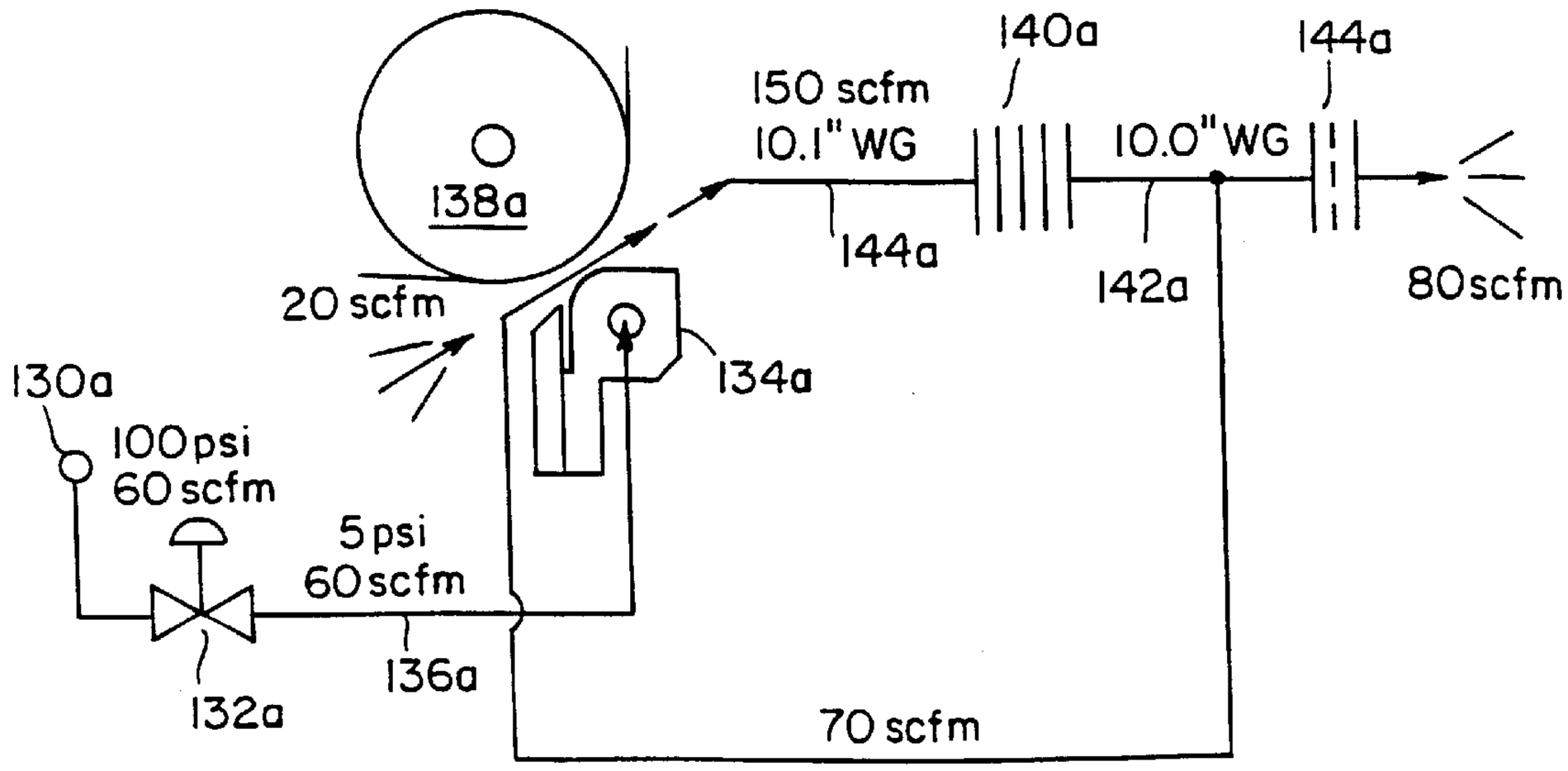

138
110 scfm
0.1" WG
140
142
144
110 scfm
50 scfm
134
130
100psi
60 scfm
5psi
60 scfm
136
132

FIG. 17


138a
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10.1" WG
140a
144a
10.0" WG
144a
142a
80scfm
20 scfm
134a
130a
100psi
60 scfm
5psi
60scfm
136a
132a
70 scfm

FIG. 18

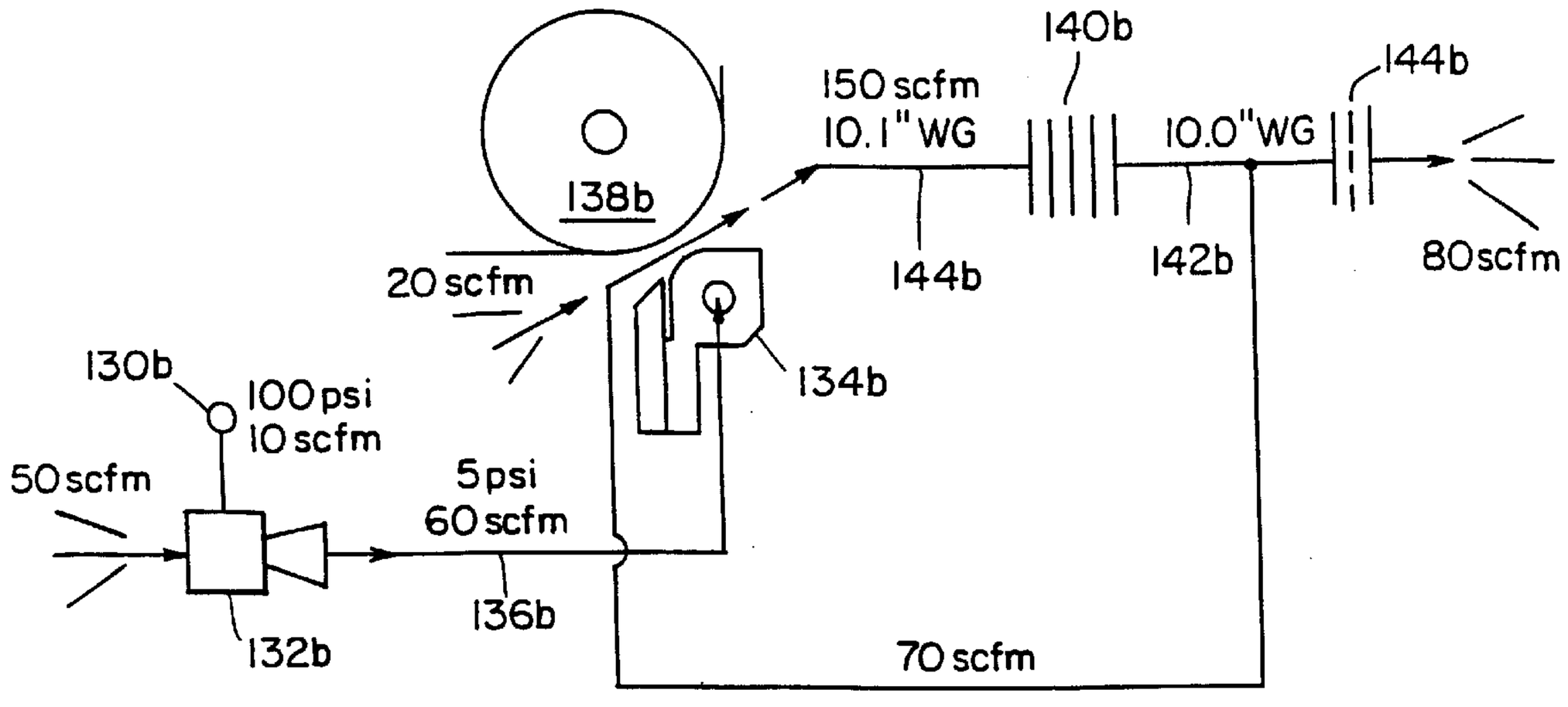
140b
144b
150 scfm
10.1"WG
10.0"WG
138b
144b
142b
80scfm
20 scfm
134b
130b
100psi
10 scfm
50scfm
5psi
60 scfm
136b
132b
70 scfm

FIG. 19

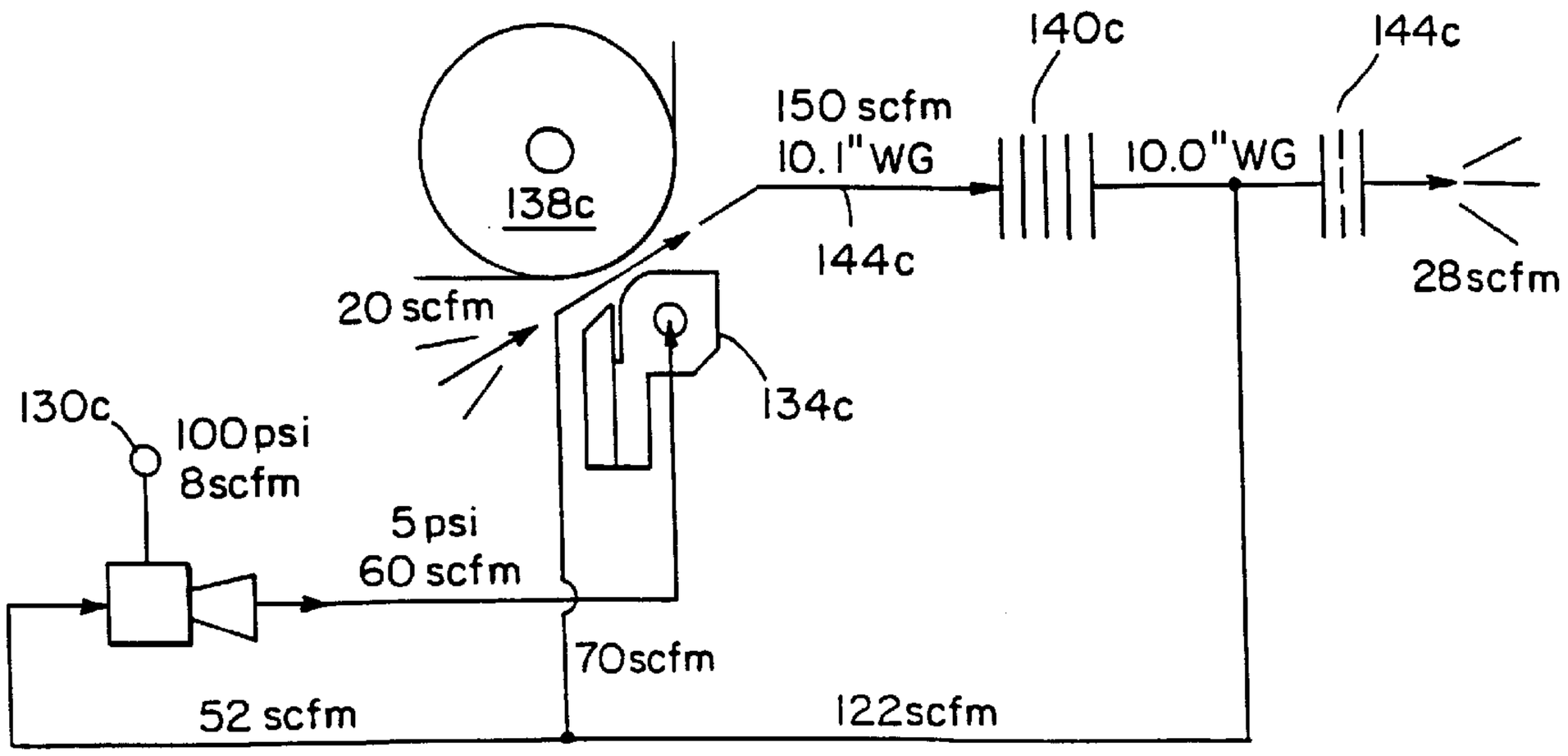
140c
144c
150 scfm
10.1"WG
10.0"WG
138c
144c
28scfm
20 scfm
134c
130c
100psi
8scfm
5 psi
60 scfm
70scfm
52 scfm
122scfm

FIG. 20

SURFACE CLEANER AND COLLECTOR SYSTEM

FIELD OF INVENTION

This invention relates to a surface cleaner and collector system and more particularly to such a system which can clean the surface of a web or plate of material. Applicant has filed Disclosure Document No. 343,572 filed Nov. 29, 1993.

BACKGROUND OF INVENTION

In manufacturing their products many industries utilize a web, which is a sheet of material that moves from one roll to another. Generally, the material is paper, plastic, woven fabric, or non-woven fabric; however, a web could be formed of any number of other suitable materials. These industries have found that product quality, plant safety and facility maintenance improve if the webs are cleaned. Web debris can cause a variety of problems, such as: interfering with the web process by leaving defects in the product; accumulating on the web processing equipment and preventing proper operation or producing a fire hazard; and contaminating the sterile environments required in certain applications.

Prior web cleaning systems operate by blowing off, vacuuming, wiping or brushing the debris from the web. Also, other systems have used an ultrasonic whistle and electrostatic repulsion. However, each of these systems has its shortcomings.

Blow-off type systems operate without any provision to collect the debris that is removed from the web. Therefore, the removed debris can cause problems by its presence in the air, or by settling on surfaces in the vicinity of the web.

Vacuum type systems require a vacuum motor nearby the web and/or bulky vacuum hoses or ducts which are utilized to transport the removed debris to a remote collector system. These systems are typically bulky, very loud, require a substantial amount of electrical energy to operate and produce excess heat at the vacuum motor. Moreover, these systems are often ineffective at separating debris from the web due to the difficulty in obtaining a layer of air at the surface that is moving at a speed sufficient to agitate the debris.

Combined vacuum and blow-off systems are somewhat effective at removing and capturing debris, but still suffer from the problems of vacuum motors, hoses, and space for a collector system. Furthermore these systems tend to be relatively expensive.

Wiping and brushing systems require that the web be mechanically contacted and therefore often disturb the web surface. Thus, these types of contact systems are not suitable for all types of web processes.

Ultrasonic whistle systems may provide a more effective blow-off than other types of systems, but they still rely on a vacuum to collect the removed debris. Therefore, these systems have the same shortcomings as the vacuum systems.

Electrostatic repulsion systems are not effective for all types of webs and generally do not remove all types and sizes of particles. In addition, control of the electrostatic repulsion process is generally difficult.

Moreover, while these systems do provide means for cleaning a web surface, albeit rather ineffectively, none of the prior art systems are useful in determining the source of the debris.

SUMMARY OF INVENTION

It is therefore an object of this invention to provide an improved surface cleaner and collector system.

It is a further object of this invention to provide such a surface cleaner and collector system which removes debris from a surface efficiently without contaminating the environment with the removed debris.

It is a further object of this invention to provide such a surface cleaner and collector system cleaning system which removes the debris within a sealed system, thereby preventing escape of the debris from the system.

It is a further object of this invention to provide such a surface cleaner and collector system which removes debris without the need for bulky, loud, and expensive vacuum equipment.

It is a further object of this invention to provide such a surface cleaner and collector system which removes debris without requiring mechanical rubbing or brushing contact with the surface to be cleaned.

It is a further object of this invention to provide such a surface cleaner and collector system which is relatively compact in size and does not release excess heat near the cleaning operation.

It is a further object of this invention to provide such a surface cleaner and collector system which provides a high velocity shearing action of the air at the surface for effectively separating the debris from the surface.

It is a further object of this invention to provide such a surface cleaner and collector system which is capable of showing the pattern of debris on the surface, which is useful as an analytical tool in determining the source of debris.

This invention results from the realization that an improved surface cleaner and collector system can be achieved by providing a sealed chamber having a positive pressure therein and having an opening for receiving a surface to be cleaned, providing at least one pressurized air delivery system proximate the surface for establishing an air flow for loosening and entraining contaminants on the surface, and providing a collector for trapping the entrained contaminants and passing the air flow.

This invention features a surface cleaner and collector system. The system includes a chamber having an opening for receiving a surface to be cleaned. There is a pressurized air delivery system proximate the surface for establishing an air flow for loosening and entraining contaminants on the surface. There is a sealing system for sealing the chamber and creating a positive pressure therein. There is also a collector for trapping the entrained contaminants and passing the air flow.

In a preferred embodiment the surface may be a web or a plate. There may further be included a surface delivery system for transporting the surface through the opening in the chamber. The surface delivery system may include an idler roller, at least a portion of which is positioned within the opening of the chamber, for supporting the surface and introducing it to the chamber. The surface delivery system may include a plurality of air expulsion passages on the surface of the air delivery system and means for introducing an air flow to the surface delivery system and the air expulsion passages to establish a cushion of air between the surface delivery system and the surface to be cleaned. There may further be included a static eliminator system for reducing the static electricity which binds the contaminants to the surface. The static eliminator system may include at least two static eliminator bars positioned on opposite sides of the surface. The air delivery system may include at least one air delivery device positioned proximate the surface. The air delivery device may be positioned 0.002 to 0.500 inches from the surface. The air delivery device may have a

length substantially equal to the width of the surface to be cleaned. The at least one air delivery device may include a Coanda air knife. The air delivery system may include two spaced air delivery devices positioned proximate the surface. The air delivery devices may be positioned 0.002 to 0.500 inches from the surface. The air delivery devices may include Coanda air knives. There may further be included a manifold interconnected with one end of the two air delivery devices for supplying air thereto. There may further be included two manifolds, one manifold being interconnected with one end of each air delivery device and the second manifold being interconnected with a second end of each air delivery device. The two air delivery devices may have lengths substantially equal to the width of the surface to be cleaned. The sealing system may include edge seals. The edge seals may include a gap formed by locating the sides of the surface delivery system no greater than approximately 0.200 inches from the edges of the chamber thereby limiting the escape of contaminants. The edge seals may include at least two air delivery devices in close proximity to both ends of the surface delivery system for sealing the edges of the chamber proximate the edges of the surface. The collector may include a filter for trapping the entrained contaminants and passing the air flow. The filter may be located proximate the surface and in a confronting relationship with respect to the surface so that the pattern of contaminants on the surface is depicted on the filter surface. The collector may include a collector vessel which is located remotely from the chamber for collecting the entrained contaminants. There further be included a conduit for interconnecting the chamber and the remote collector vessel. The collector vessel may include a filter for trapping any uncollected entrained contaminants and for passing the air flow. There may further be included means for recirculating the passed air flow from the collector and for introducing a recirculated air flow into the air flow established by the air delivery system. The means for recirculating may include means for filtering the recirculated air flow. The means for recirculating may include collector means for collecting heavier contaminants entrained in the passed air flow. The means for recirculating may include output regulator means for recirculating a portion of the passed air flow to increase the air flow and exhausting the remaining air flow to the atmosphere. There may further be included a filter carrier system for removably positioning the filter proximate the chamber. The filter carrier system may include a removable filter carrier assembly for supporting the filter and a filter carrier assembly receiving means for receiving the filter carrier assembly. The filter carrier assembly may include a plurality of pressure clips which engage a like plurality of pressure clips on the filter carrier receiving means for securing the filter carrier assembly in place. There may further be included means for adjusting the spacing between the air delivery devices and the surface. The means for adjusting may include means for rotatably positioning the air delivery devices proximate the surface, wherein the means for positioning is hinged at one end and moveable at its other end such that the spacing between each said air delivery device and the surface remains substantially equal throughout the adjustment range. The chamber may include a moveable flapper for directing the air flow within the chamber. The collector may include at least two filters and the moveable flapper may be positionable to direct the air flow to either filter or both. There may further be included a second surface cleaning system for cleaning the opposite surface of the surface to be cleaned including: a second chamber having an opening for receiving the opposite surface; at least one pressurized air delivery system in the second chamber proximate the opposite surface for establishing an air flow for loosening and entraining contaminants on the opposite surface; a sealing system for sealing the second chamber and creating a positive pressure therein; and a collector for trapping the entrained contaminants and passing the air flow. The sealing system for the second chamber may include edge seals. The edge seals may include a gap formed by positioning the ends of the surface delivery system in close proximity to the edges of the second chamber thereby limiting the escape of contaminants. The edge seals may include at least two pressurized air delivery devices in close proximity to both edges of the opposite surface for sealing the edges of the second chamber proximate the edges of the opposite surface. The air delivery system may include a source of compressed air for establishing an air flow to the air delivery devices and a regulator device for regulating the air flow to the air delivery devices. The regulator device may include an air amplifier for entraining air to decrease the air supplied from the source of compressed air. There may further be included means for recirculating the passed air flow from the collector. The means for recirculating may include output regulator means for recirculating a portion of the passed air flow, exhausting a portion of the air flow to the atmosphere and entraining a portion of the air flow into the air amplifier. There may further be included an enclosure for enclosing the surface cleaner system. The pressurized air delivery system may include a shaped air delivery device for providing the air flow about the periphery of the chamber. The shaped air delivery device may be circular.

This invention also features a surface cleaner and collector system which includes a chamber having an opening for receiving a surface to be cleaned. There are first and second opposing pressurized air devices proximate the surface for establishing an air flow for loosening and entraining contaminants on the surface. There is a sealing system for sealing the chamber and creating a positive pressure therein. The sealing system includes circular and/or multiple inward-directed pressurized air devices. There is a filter for trapping the entrained contaminants and passing the air flow.

This invention further features a surface cleaner and collector system which includes a chamber having an opening for receiving a surface to be cleaned. There are first and second opposing Coanda air knives proximate the surface for establishing an air flow for loosening and entraining contaminants on the surface. There is a sealing system for sealing the chamber and creating a positive pressure therein. There is also a collector for trapping said entrained contaminants and passing the air flow.

This invention additionally features a surface cleaner and collector system which includes a chamber having an opening for receiving a surface to be cleaned. There are first and second opposing Coanda air knives proximate the surface for establishing an air flow for loosening and entraining contaminants on the surface. There is a sealing system for sealing the chamber and creating a positive pressure therein. The sealing system includes third and fourth opposing Coanda air knives in close proximity to both edges of the surface. There is a collector for trapping the entrained contaminants and passing the air flow.

This invention further features a surface cleaner and collector system. The system includes a chamber having an opening for receiving a surface to be cleaned. There is a shaped air delivery system proximate the surface for establishing an air flow about the periphery of the chamber for loosening and entraining contaminants on the surface. There is a sealing system for sealing the chamber and creating a

positive pressure therein and a collector for trapping the entrained contaminants and passing the air flow. In a preferred embodiment the shaped air delivery system is circular.

This invention also features a cleaner and collector system for cleaning opposite surfaces of an object. The system includes a first chamber having an opening for receiving a first surface of the object to be cleaned. There is a first pressurized air delivery system proximate the first surface for establishing an air flow for loosening and entraining contaminants on the first surface. There is a sealing system for sealing the first chamber and creating a positive pressure therein. There is a first collector for trapping the entrained contaminants and passing the air flow. There is further included a second chamber having an opening for receiving a second, opposite surface of the object to be cleaned and a second pressurized air delivery system proximate the second, opposite surface for establishing an air flow for loosening and entraining contaminants on the second, opposite surface. There is a second sealing system for sealing the second chamber and creating a positive pressure therein. There is also a second collector for trapping the entrained contaminants and passing the air flow.

This invention further includes a surface cleaner and collector system which includes a chamber having an opening for receiving a surface to be cleaned and a pressurized air delivery system proximate the surface for establishing an air flow for loosening and entraining contaminants on the surface. There is a sealing system for sealing the chamber and creating a positive pressure therein and a collector vessel located remotely from the chamber for collecting the entrained contaminants and passing the air flow.

This invention further features a surface cleaner and collector system which includes a chamber having an opening for receiving a surface to be cleaned. The system includes a pressurized air delivery system proximate the surface for establishing an air flow for loosening and entraining contaminants on said surface. There is a sealing system for sealing the chamber and creating a positive pressure therein and a collector for trapping the entrained contaminants and passing the air flow. The collector includes at least two filters and a movable flapper which is positionable to direct the air flow to either filter or both.

DISCLOSURE OF PREFERRED EMBODIMENT

Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in which:

FIG. **1** is a three-dimensional view of a surface cleaner and collector system according to this invention;

FIG. **2** is a three-dimensional partially cut away view of a portion of the surface cleaner and collector system of FIG. **1**;

FIG. **3** is a cross-sectional view of the surface cleaner and collector system shown taken along line **2**—**2** of FIG. **2**;

FIG. **3**A is a three-dimensional view of the bottom surface of the filter and surface shown in FIGS. **2** and **3**;

FIG. **4**A is a three-dimensional view of an alternative air delivery device;

FIG. **4**B is a three-dimensional view of another alternative air delivery device;

FIG. **5** is a three-dimensional view of a Coanda air knife;

FIG. **6**A is a schematic view of one configuration of the air delivery system of this invention;

FIG. **6**B is an alternative configuration of the air delivery system used in this invention;

FIG. **7**A is a partial three-dimensional view of the filter and filter carrier assembly according to this invention;

FIG. **7**B is an end view of the cover housing, filter and filter carrier assembly according to this invention;

FIG. **8**A is a front cross-sectional view of the surface cleaner and collector system of FIG. **2** depicting the end seals;

FIG. **8**B is a front cross-sectional view of the surface cleaner and collector system of FIG. **2** depicting active end seals;

FIG. **9** is a cross-sectional view of the surface cleaner and collector system taken along line **2**—**2** of FIG. **2** depicting the gap adjustment means;

FIG. **10** is a cross-sectional view of an alternative two-filter configuration according to this invention;

FIG. **11** A is a partial cross-sectional view of an alternative to an idler roller which suspends the surface to be cleaned above a stationary surface by a cushion of air;

FIG. **11**B is a partial cross-sectional view of a surface cleaner and collector system according to this invention utilizing the configuration of FIG. **11**A;

FIG. **12**A is a side cross-sectional view of an alternative embodiment of the surface cleaner and collector system according to this invention for use in cleaning a flat web or surface;

FIG. **12**B is a partial cut away view of the surface cleaner and collector system of FIG. **12**A;

FIG. **13**A is a top partially cut away view of the surface cleaner and collector system of FIG. **12**A including two additional air knives positioned proximate the edges of the surface to be cleaned to achieve active edge sealing;

FIG. **13**B is a three-dimensional, partially cut away view of an alternative embodiment of the surface cleaner and collector system of FIG. **13**A;

FIG. **14** is a schematic view of an alternative embodiment of a surface cleaner and collector system according to this invention which includes a remotely located canister and filter for collecting contaminants;

FIG. **15** is an alternative embodiment of a surface cleaner and collector system according to this invention for simultaneously cleaning opposite surfaces;

FIG. **16** is a three dimensional view of the surface cleaner and collector system of FIG. **12**A or FIG. **15** within an enclosure;

FIG. **17** is a schematic view of the basic air supply system of this invention;

FIG. **18** is a schematic view of a recirculated air supply system of this invention with a regulated output;

FIG. **19** is a schematic diagram of the air supply system of this invention utilizing an air amplifier; and

FIG. **20** is a schematic diagram of an alternative recirculated air flow system according to this invention.

There is shown in FIG. **1** a surface cleaner and collector system **10** which may be used to clean the surface of web **12**. System **10** includes cover housing and base portion generally designated as **14** and **16**, respectively. Although not shown, base portion **16** is typically mounted to some sort of support structure. Cover housing **14** is pivotally interconnected with base frame **17** and **17'** of base portion **16** and pivots about pivot member **18** and a corresponding pivot member (not shown) at the other end of base portion **16** and cover housing **14**. Pistons **20** and **22**, which are interconnected at their first ends with cover housing **14** and at their second ends with end walls **19** and **19'**, control the position

of cover housing **14** with respect to base portion **16**. As the pistons are extended, cover housing **14** is moved into an open position as shown in FIG. **1**, and when the pistons are retracted cover housing **14** is moved into a closed position as shown in FIG. **2**. Pistons **20** and **22** are operated under pneumatic control or by air pressure supplied to the pistons by lines **21**. In the closed position, cleaning of web surface **12** can be effected as described in detail below by establishing a positive pressure chamber within cover housing **14** and introducing pressurized air to the surface of web **12**.

Idler roller support **23** mounted on base frame **17** of base portion **16** rotatably supports idler roller **24** which in turn supports web **12** and enables movement of web **12** through surface cleaner and collector system **10**, in this example, in the direction of arrow **26**; however, web **12** could be passed through system **10** in either direction. As web **12** is moved into surface cleaner and collector system **10** it passes in close proximity to a pair of static eliminator bars **26** and **28**, supplied with a potential over lines **27** and **29**, respectively, to create ionized air to remove static electric charge on the web **12** and debris to be removed from the surface of web **12** before it enters system **10**.

Cover housing **14** includes manifolds **30** and **32** which supply an air flow to one or more air sources within cover housing **14** as shown in detail in FIGS. **6**A and **6**B. Cover housing **14** also includes filter **34** for collecting debris such as contaminants removed from web **12** and filter carrier assembly **36** which enables easy installation and removal of filter **34**.

A partial cross-sectional view along both the length and width of cover housing **14** in the closed, cleaning position is shown in FIG. **2**. In this position, cover housing **14** is closed and covers a portion of the surface of web **12**. Pressurized air sources **38** and **40** (shown in phantom) which supply a pressurized airflow indicated at arrows **39** to the surface of web **12** to remove debris, peripheral seal **42**, filter **34** which filters the removed debris and allows the air flow to pass, and the end seals described below with regard to FIGS. **8**A and **8**B, establish positive pressure chamber **43** (i.e. above atmospheric) which is described in more detail below with regard to FIG. **3**. The pressurized air sources are typically located approximately 0.002 to 0.500 inches from the surface. Creating positive pressure chamber **43** enables effective and clean removal of contaminants or particulate matter from the surface of web **12** without the need for powerful and noisy vacuum systems or the need to mechanically contact the surface being cleaned as required in prior art systems.

A cross-sectional view of cover housing **14** and idler roller **24** in FIG. **3** illustrates the surface cleaning operation within positive pressure chamber **43**. As noted above, positive pressure chamber **43** is created by air sources **38** and **40** in conjunction with peripheral seal **42** and filter **34** which is positioned by filter carrier sides **86** and **88**. Idler roller **24** rotates as web **12** moves past air sources **38** and **40**, both of which provide a high pressure airflow **39** which impinges on the surface of web **12** and which provides an increased positive pressure in chamber **43**. Air flow **39** causes scrubbing of surface **12** and removal and entrainment of contaminants **44** from the surface of web **12**. The positive pressure in chamber **43** drives air **39** with entrained contaminants **44** through filter **34** which removes the contaminants and passes the air in the direction of arrows **46** and **48** through air return ducts **50** and **52** to outlets **54** and **56** where it is introduced into the air stream indicated by arrows **55** and **57** and is drawn back into positive pressure chamber **43**. Excess air is vented at the ends of ducts **50** and **52** at the open ends of cover **14**. As an alternative to recirculating the air flow, ducts **50** and **52** could be eliminated by providing walls **47** shown in phantom which direct the air flow through an opening in cover housing **14**. In another alternative configuration, filter **34** may be omitted or replaced by a coarse filter with the addition of a collector **51**, shown in phantom, which may be provided to collect contaminants **44** that pass through filter **34** and mesh screen **49**. A second filter **53**, also shown in phantom, may be provided to further filter the air flow to remove any contaminants not collected by filter **34** or collector **51**.

In yet another alternative configuration, filter **34'** could be located remotely from cover housing **14** in, for example, canister **35**, shown in phantom, which is interconnected with positive pressure chamber **43** by duct **37**, also shown in phantom. Duct **37** transports entrained contaminants **44** to canister **35** where they are collected. The air flow from positive pressure chamber **43** passes through filter **34'** and out into the atmosphere.

As shown in FIG. **3**A the bottom surface of filter **34** which receives the incoming air flow with entrained contaminants typically will include distinct areas of contaminants **44** (type A) and **44'**, which may be a different type of contaminant (type B), in positions which correspond to the location of the contaminants on the surface of web **12**. It is possible to observe the pattern of contaminants on the surface of filter **34** and use this pattern as an analytical tool in determining the source of contaminants on web **12**, as the contaminants do not diverge much from web **12** to the surface of filter **34**. In this figure filter **34** is shown rotated to illustrate collection of contaminants and surface **12**, although shown in FIGS. **1** and **2** being transported around idler roller **24**, is shown in a flat configuration for illustration purposes.

Although in the particular embodiment shown in FIGS. **2** and **3**, two air sources **38** and **40** are used, in fact, only one could be a pressurized air source; the other one could be a conventional sealing device. Further, in this figure both air sources **38** and **40** are Coanda type air knives which cause the air coming out of narrow slits **58** and **60** to follow the curvature of surfaces **62** and **64** of air sources **38** and **40**. The construction of air sources **38** and **40** is described in more detail below with regard to FIG. **5**. Although Coanda air knives are the preferred type of air source, conventional air knives such as **38***a* shown in FIG. **4**A, or even a series of nozzles such as **38***b* shown in FIG. **4**B, can be used.

The preferred Coanda type air knife **38**, FIG. **5**, includes a channel **66** which receives pressurized air from manifold **30** or **32**, FIG. **1**, or both, as shown in FIGS. **6**A and **6**B. In FIG. **6**A, channel **66** of air knife **38** and channel **68** of air knife **40** are interconnected with channel **65** of manifold **30** at one of their ends which supplies channels **66** and **68** with pressurized air. At the other ends of channels **66** and **68** are plugs **69** and **70**. Manifold **30** receives pressurized air at inlet **71** of channel **65** and includes a plug **72** at the opposite end on channel **65**. In FIG. **6**B channels **66** and **68** of air knives **38** and **40** are connected at their first end with manifold **30** which supplies the channels with pressurized air and at their second ends with manifold **32** which also supplies channels **66** and **68** with pressurized air introduced into inlet **73** of channel **74**. The other end of channel **32** of manifold **74** is sealed by plug **75**. Referring again to FIG. **5**, channel **66** terminates in exit slot **58** defined by an area formed by machining or the use of a shim between cover portion **76** and base portion **78** of air knife **38**. Slot **58** forces the air out in the direction of arrows **67** so that it impinges upon on the surface of web **12** (not shown in this figure). Because surface **62** of base portion **78** extends beyond the termination of

cover portion **76**, atmospheric pressure which is higher than the pressure of the air flow, causes a positive pressure in the direction of surface **62** causing the air flow **67** to follow the contour of surface **62**. This effect is often referred to as the Coanda effect and air knives which operate in this manner are generally referred to as Coanda air knives.

Filter **34** and filter carrier assembly **36** are partially shown in more detail in FIGS. **7**A and **7**B. Filter **34**, FIGS. **7**A and **7**B, is installed through an opening **80** in the underside of filter carrier assembly **36** and is retained therein by means of frictional contact with seals **82** and **84** and upper surfaces **86** and **88** of filter carrier assembly **36**. Filter carrier assembly **36** includes handle **90** which enables easy installation and removal of it from cover housing **14**. Filter carrier assembly **36** includes top pressure clips **91** and **92** at its first end and two other pressure clips (not shown) at its other end. It also includes four side pressure clips, only two of which, clips **93** and **94**, are shown in these figures. These clips engage complementary clips **95–98** within cover housing **14** located near its first end to secure the assembly in place. There are also four other complementary clips within cover housing **14**, (not shown) located near its other end which engage the four pressure clips on filter carrier assembly **36** which are also not shown. Assembly **36** is seated upon peripheral seal **42**.

FIG. **8**A depicts the air seals formed at the ends of idler roller **24** by close gaps **100** and **101** which are approximately 0.005 in. to 0.100 in. The close gaps restrict the air escape from chamber **43** to minimize the unwanted release of contaminants **44**. When filter **34** provides little back-pressure to chamber **43**, and when there is adequate air flow through the filter **34**, the close gaps **100** and **101** can allow entrainment of air moving into chamber **43**, thus providing an effective seal. Alternatively, the end seals may be actively achieved by providing additional air sources, such as air knives **102** and **104**, FIG. **8**B, at the ends of idler roller **24** to provide an additional air flow into and seal the ends of chamber **43**. Air knives **102** and **104** also serve as manifolds to supply air to air sources **30** and **32**. Also alternatively, the end seals to the idler roll may be accomplished by any of the mechanical seal systems known to those skilled in the art.

Surface cleaner and collector system **10**, as shown in FIG. **9**, allows for the adjustment of gaps **105**, **106** between the surface of web **12** and air sources **38** and **40**. This is accomplished by adjusting set screws **108** (within end walls **19** and **19'**) which contact manifolds **30** and **32** of cover housing **14** by using hex wrench **110**. Adjusting set screws **108** moves the closed position of cover housing **14** more open or closed by contacting manifolds **30** and **32**. Cover housing **14** pivots about pivot point **18**, but because of the selected geometry, when one end of the cover housing **14** is raised and the other end swings about pivot **18** both gaps **105** and **106** remain essentially equal in size throughout the adjustment range.

In an alternative embodiment, surface cleaner and collector system **10***a*, FIG. **10**, can be equipped with two filters **34***a* and **34***a*' which are set upon peripheral seals **42***a* and **42***a*'. There is a divider member **112** which pivots about point **113** to divide positive pressure chamber **43***a* into two sections and to divide the air flow between the two filters **34***a* and **34***a*'. Also, divider member **112** may be moved into contact with either peripheral seal **42***a* or **42***a*' to prevent the air flow through either filter **34***a* or **34***a*' so that the filters may be changed without interrupting the surface cleaning process.

An alternative to the idler roller is a stationary surface **24***a*, FIGS. **11**A and **11**B, which includes a plurality of air vents **114–116** on its surface for creating an air cushion in gap **117** formed between surface **24***a* and web **12** for floating web **12** above the surface **24***a*. This type of surface can be used in those applications which require that the web not contact the idler roller. As shown in FIG. **11**B, air flotation bar **23***a*, which supports stationary surface **24***a*, includes a port **118** for interconnecting with a pressurized air source to provide vents **114–116** with a pressurized air flow. In this configuration, end seals **100** and **101** can be made by contact, since there is no relative motion of the surfaces.

An alternative embodiment of this invention is shown in FIGS. **12**A and **12**B where surface cleaner and collector system **10***a* is configured to clean a flat surface such as web or plate **12***a*. This system is configured similarly to surface cleaner and collector system **10**, FIG. **1**, as it includes a cover housing **14***a* which includes therein sealed positive pressure chamber **43***a* established by air sources **38***a*, **40***a*, filter **34***a* and peripheral seal **42***a*. Pressurized air indicated at arrows **39***a* impinges upon the surface of web or plate **12***a* to remove and entrain contaminants and carry them into filter **34***a* where they are retained as the air flow passes through the filter. Side walls **120** and **122** support filter **34***a*, air sources **38***a* and **40***a* and provide seals to the surface.

Another alternative embodiment of this invention, surface cleaner and collector system **10***b*, is shown in FIG. **13**A. In this embodiment, there are included two air sources **38***b*, **40***b* (not shown) which provide an air flow parallel to the direction of web movement indicated by arrow **121** and two other air sources **122** and **124** which provide an air flow perpendicular to the direction of web movement. These two additional air sources provide additional sealing of positive pressure chamber **43***b* as well as additional scrubbing of web **12***b* and entrainment of contaminants and the combination of air sources form a peripheral boundary of air flow directed toward chamber **43***b* and surface **126**. It will be apparent to those skilled in the art that the same effect can be accomplished by the use of a number of air sources arranged to provide the same effect.

Surface cleaner and collector system **10***b*', FIG. **13**B, is an alternative embodiment to the surface cleaner and collector system **10***b*, FIG. **13**A. Air source **38***b*' is circularly shaped such that it provides a peripheral boundary of air flow directed toward surface **12***b*' and chamber **43***b*'. Shaped air source **38***b*' could be formed in one continuous piece or it could be formed of several component pieces. Moreover, air source **38***b*' need not be circular and it may be formed of various shapes which will apparent to those skilled in the art. Air source **38***b*' is a Coanda type air knife which is composed of a cover portion **76***b*' and a base portion **78***b*' with channel **66***b*' formed therein terminating in exit slot **58***b*'. Compressed air is supplied to channel **66***b*' by means of air supply **30***b*'. Air exiting exit slot **58***b*' is shown at arrow **67***b*' to impinge upon the surface **12***b*', travel through chamber **43***b*' and circular filter **34***b*'. Although the air source **38***b*' in this figure is shown to be of the Coanda type any of the alternative configuration, such as those shown in FIGS. **4**A and **4**B can be used.

Placing a filter proximate the web surface to be cleaned is not a necessary limitation of this invention. As shown in FIG. **14** surface cleaner and collector system **10***c* does not utilize a filter within cover housing **14***c*, but rather there is included exhaust port **125** through which entrained particles are removed and delivered to a remotely located bulk canister **126**, for example, where the removed particles **44***c* are collected. The exhaust air indicated at arrows **127** flows through filter **128** to remove any entrained contaminants not collected in bulk canister **126**.

Both sides of a flat surface such as web or plate **12***d*, FIG. **15**, can be cleaned by positioning surface cleaner and collector system **10***d* on the upper surface of web **12***d* and surface cleaner and collector system **10***d*' on the lower surface.

As shown in FIG. **16** surface cleaner and collector system **10***d* and, optionally, surface cleaner and collector system **10***d*' may be contained within an enclosure **130**. Air vents **132** and **134**, for example, on the top and bottom surfaces of enclosure **130**, respectively, may be included to allow the air flow generated by the air sources to escape from the enclosure after filtration. Also included are side walls **120***b*, **122***d* and **120***d*' and **122***d*' (not shown) to support the air sources, and/or provide a manifold function, and/or provide seals.

FIGS. **17–20** illustrate various ways of obtaining better efficiency of the air supply. The pressure and flow rate numbers used are only exemplary. Those skilled in the art could obtain more realistic numbers based on actual energy available with the compressed air and energy losses that would take place in a system of this type.

Air supply **130**, FIG. **17**, supplies a 100 psi air flow at 60 scfm (standard cubic feet per minute) to regulator **132** which provides a regulated air flow of 5 psi at 60 scfm to air knife **134** over line **136**. In these FIGS., **17–20**, the air supply is shown schematically to be supplied over a line, however, this air supply would actually be provided over a line to a manifold, as described above, which would in turn supply the air sources with the pressurized air. In the small gap between air source **134** and idler roller **138** is entrained approximately 50 scfm of air from the atmosphere which in combination with the supplied air flow impinge upon the surface of the web supported by idler roller **138** and entrain contaminants which with the airflow travel into filter **140**. As can be seen at arrow **142**, 110 scfm of air is exhausted to the atmosphere. With this configuration, a positive pressure of approximately 0.1 inch WG (water gauge) in positive pressure chamber **144** is achieved, a result of back-pressure through filter **140**.

A slightly different configuration which recirculates a portion of the air flow from the filter is shown in FIG. **18**. Here, air supply **130***a* also supplies 100 psi at 60 scfm to regulator **132***a* which in turn supplies a regulated air flow to air source **134***a* over line **136***a*. In this configuration 60 scfm is supplied by air source **134***a*, 20 scfm of air flow is entrained from the atmosphere and 70 scfm is recirculated from the air flow out of filter **140***a*. The airflow output of filter **140***a* is 150 scfm, but because output regulator **144***a* is utilized only 80 scfm is exhausted to the atmosphere while the remaining 70 scfm is recirculated to be used to scrub the surface of the web on idler roller **138***a*. With this configuration an increase in positive pressure from 0.1 inch WG to 10.1 inches WG is achieved in positive pressure chamber **144***a*, 0.1 inch WG as a result of back pressure through filter **140***a*, and 10 inches WG as a result of output regulator **144***a*.

A configuration similar to that of FIG. **18** is depicted in FIG. **19**; however, instead of utilizing a regulator, an air amplifier **132***b* is utilized. The air amplifier entrains 50 scfm of air from the atmosphere and only requires an air supply of 100 psi at 10 scfm as an input in order to supply over line **136***b* 5 psi at 60 scfm. This air amplifier configuration could be utilized in the system of FIG. **17**. In the configuration shown in FIG. **20** air amplifier **132***c* is utilized and as in FIG. **19** only requires an air supply from **130***c* of 100 psi at 8 scfm to supply the same regulated output of 5 psi at 60 scfm. However, instead of entraining 50 scfm of air from the atmosphere, 52 scfm is recirculated from regulator **144***c*. Regulator **144***c* provides a regulated output of 28 scfm to the atmosphere and recirculates 70 scfm back to the input of the positive pressure chamber **144***c* to be combined with the 20 scfm which is entrained from the atmosphere and the 60 scfm which is supplied from air source **134***c*.

Although specific features of this invention are shown in some drawings and not others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention. Other embodiments will occur to those skilled in the art and are within the following claims:

What is claimed is:

1. A surface cleaner and collector system comprising:

a chamber having an opening for receiving a surface to be cleaned;

a pressurized air delivery system proximate said surface for establishing an air flow for loosening and entraining contaminants on said surface;

a collector for trapping said entrained contaminants and passing the air flow, the entrained contaminants directed to said collector preventing their escape from said system;

a sealing system for sealing said collector with respect to said chamber; and

a delivery system for transporting the surface through the opening in said chamber.

2. The surface cleaner and collector system of claim **1** in which said surface delivery system includes an idler roller, at least a portion of which is positioned within the opening of said chamber, for supporting the surface and introducing it to said chamber.

3. The surface cleaner and collector system of claim **1** further including a static eliminator system for reducing the static electricity which binds the contaminants to the surface.

4. The surface cleaner and collector system of claim **3** in which said surface to be cleaned is one side of a thin material having two sides, a side to be cleaned and a side not to be cleaned, and said static eliminator system including at least two static eliminator bars proximate each of said sides, said thin material positioned therebetween.

5. The surface cleaner and collector system of claim **1** in which said air delivery system includes at least one air delivery device positioned proximate the surface.

6. The surface cleaner and collector system of claim **5** in which said air delivery device is positioned 0.002 to 0.500 inches from the surface.

7. The surface cleaner and collector system of claim **5** in which said air delivery device has a length substantially equal to the width of the surface to be cleaned.

8. The surface cleaner and collector system of claim **5** in which said at least one air delivery device includes a Coanda air knife.

9. The surface cleaner and collector system of claim **1** in which said air delivery system includes two spaced air delivery devices positioned proximate the surface.

10. The surface cleaner and collector system of claim **9** which said air delivery devices are each positioned 0.002 to 0.500 inches from the surface.

11. The surface cleaner and collector system of claim **9** in which said air delivery devices include Coanda air knives.

12. The surface cleaner and collector system of claim **9** further including a manifold interconnected with one end of said two air delivery devices for supplying air thereto.

13. The surface cleaner and collector system of claim **9** further including two manifolds, one manifold being inter-

connected with one end of each said air delivery device and the second manifold being interconnected with a second end of each said air delivery device.

14. The surface cleaner and collector system of claim **9** in which said two air delivery devices have lengths substantially equal to the width of the surface to be cleaned.

15. The surface cleaner and collector system of claim **9** further including means for adjusting the spacing between said air delivery devices and said surface.

16. The surface cleaner and collector system of claim **15** further including a surface delivery system for transporting the surface through the opening in said chamber in which said means for adjusting includes means for rotatably positioning said air delivery devices proximate the surface, wherein said means for positioning is hinged to said surface delivery system at one end and movable at its other end such that the spacing between each said air delivery device and said surface remains substantially equal throughout adjustment.

17. The surface cleaner and collector system of claim **1** in which said sealing system includes end seals for sealing said collector and said chamber with respect to said surface delivery system.

18. The surface cleaner and collector system of claim **17** in which said end seals include a gap formed by locating the ends of said surface delivery system no greater than approximately 0.200 inches from the opening of said chamber thereby limiting the escape of contaminants.

19. The surface cleaner and collector system of claim **17** in which said edge seals include at least two air delivery devices in close proximity to both ends of said surface delivery system for sealing the edges of said chamber proximate the edges of the surface.

20. The surface cleaner and collector system of claim **1** in which said collector includes a filter for trapping the entrained contaminants and passing the air flow.

21. The surface cleaner and collector system of claim **20** in which said filter is located proximate the surface and in a confronting relationship with respect to the surface so that the pattern of contaminants on the surface is depicted on the filter surface.

22. The surface cleaner and collector system of claim **20** further including a filter carrier system for removably positioning said filter proximate said chamber.

23. The surface cleaner and collector system of claim **22** in which said filter carrier system includes a removable filter carrier assembly for supporting said filter and a filter carrier assembly receiving means for receiving said filter carrier assembly.

24. The surface cleaner and collector system of claim **23** in which said filter carrier assembly includes a plurality of pressure clips which engage a like plurality of pressure clips on said filter carrier receiving means for securing said filter carrier assembly in place.

25. The surface cleaner and collector system of claim **1** further including means for recirculating the passed air flow from said collector and for introducing a recirculated air flow into the air flow established by said air delivery system.

26. The surface cleaner and collector system of claim **25** in which said means for recirculating includes means for filtering the recirculated air flow.

27. The surface cleaner and collector system of claim **25** in which said means for recirculating includes collector means for collecting heavier contaminants entrained in the passed air flow.

28. The surface cleaner and collector system of claim **25** in which said means for recirculating includes output regulator means for recirculating a portion of the passed air flow to increase said air flow and exhausting the remaining air flow to the atmosphere.

29. A surface cleaner and collector system comprising:

a chamber having an opening for receiving a surface to be cleaned;

a pressurized air delivery system proximate said surface for establishing an air flow pattern for loosening and entraining contaminants on said surface;

means for sealing said chamber against the escape of said entrained contaminants from said chamber, said means for sealing said chamber including end seals for sealing said collector and said chamber with respect to said surface delivery system;

a collector for trapping said entrained contaminants and passing said air flow; and

a surface delivery system for transporting the surface through the opening in said chamber.

30. The surface cleaner and collector system of claim **29** in which said means for sealing includes a pressurized air source outlet which creates a tangential air flow over said surface for creating an air flow which seals said collector against the escape of said contaminants.

31. The surface cleaner and collector system of claim **29** in which said surface to be cleaned is one side of a thin material having two sides, a side to be cleaned and a side not to be cleaned, and a static eliminator system including at least two static eliminator bars proximate each of said sides, said thin material positioned therebetween.

32. A surface cleaner and collector system comprising:

a chamber having an opening for receiving a surface to be cleaned;

a pressurized air delivery system proximate said surface for establishing an air flow for loosening and entraining contaminants on said surface;

a collector for trapping said entrained contaminants and passing the air flow, the entrained contaminants directed to said collector preventing their escape from said system;

a sealing system for sealing said collector with respect to said chamber; and

a static eliminator system for reducing the static electricity which binds the contaminants to the surface.

33. A surface cleaner and collector system comprising:

a chamber having an opening for receiving a surface to be cleaned;

a pressurized air delivery system proximate said surface for establishing an air flow for loosening and entraining contaminants on said surface, said air delivery system including two spaced air delivery devices positioned proximate the surface;

a collector for trapping said entrained contaminants and passing the air flow, the entrained contaminants directed to said collector preventing their escape from said system; and

a sealing system for sealing said collector with respect to said chamber.

34. A surface cleaner and collector system comprising:

a chamber having an opening for receiving a surface to be cleaned;

a pressurized air delivery system proximate said surface for establishing an air flow for loosening and entraining contaminants on said surface;

a collector for trapping said entrained contaminants and passing the air flow, the entrained contaminants directed to said collector preventing their escape from said system;

a sealing system for sealing said collector with respect to said chamber; and

means for recirculating the passed air flow from said collector and for introducing a recirculated air flow into the air flow established by said air delivery system.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,836,044
DATED : November 17, 1998
INVENTOR(S) : Chandler G. Sinnett and Marshall Edward Hall

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

TITLE PAGE:

Under Inventors, please replace "Mass." with --Me.--

Under Assignee, please replace "Mass." with --Me.--

Signed and Sealed this

Sixteenth Day of March, 1999

Attest:

Q. TODD DICKINSON

Attesting Officer

Acting Commissioner of Patents and Trademarks